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National Oceanic and Atmospheric Administration
Environmental Data Service

BOMEX Temporary Archive
Description of Available Data

TERRY DE LA MORINIERE

SILVER SPRING, MD.
January 1972

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National Oceanic and Atmospheric Administration

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BOMEX TEMPORARY ARCHIVE
DESCRIPTION OF AVAILABLE DATA

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ABSTRACT

This report describes the data available from the BOMEX Temporary Archive, a depository for data collected during the Barbados Oceanographic and Meteorological Experiment (BOMEX) during May, June, and July 1969. Procedures used in processing these data, inventories of the archived data, and ordering instructions and costs are given.

INTRODUCTION

Effective February 1, 1971, a temporary archive was established to service requests for processed data products resulting from the Barbados Oceanographic and Meteorological Experiment (BOMEX), conducted in the summer of 1969. Not all BOMEX data have been assembled. The temporary archive represents data selected by the Barbados Oceanographic and Meteorological Analysis Project (BOMAP) Office** that were acquired from the fixed-ship, aircraft, and island-based acquisition systems under the operational control of the BOMEX Field Headquarters. Various BOMEX principal investigators (responsible for experiments other than the BOMEX Core Experiment) acquired data during BOMEX, but these data will not be placed in the temporary archive since most are still in the possession of the investigators for processing and analysis.

The temporary archive is defined as such since it contains preliminary, unvalidated data that are being made available at an early stage in the BOMAP processing activity. It will be replaced by a permanent archive when the data-processing cycle is finished (late 1972). Validated data are defined as processed data for which the quality has been effectively demonstrated, and limitations as to space resolution, time resolution, and accuracy have been

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**Now Center for Experiment Design and Data Analysis (CEDDA).

clearly documented. Such conclusive information is not available at this time because of continuing BOMAP efforts in data-processing software development, scientific test computations, calibration studies, and intercomparison studies of data obtained from the various types of BOMEX acquisition platforms. Those requesting BOMEX data from the temporary archive should therefore be prepared to perform such quality and accuracy tests as may be required prior to use for scientific research. The BOMAP Office staff stands ready to assist in answering users' questions concerning the processing or quality of the temporary archive data products (telephone (301) 496-8871).

Table 1.0 lists the data products available through the temporary archive. This table defines the acquisition platforms or locations where the data were obtained, specifies the archive product as observed data or support documents for use in evaluating the observed data, and the form in which these data products can be obtained from the temporary archive. The various archived data types are discussed in the text that follows in the order in which they are listed in table 1-0.

Table 1-0. Contents of the BOMEX Temporary Archive

Name of BOMEX data archive product	Name of BOMEX acquisition platform or location from which data were acquired	Observed data or support data for evaluating observed data	Available forms(s) of archive products				Remarks
			Magnetic tape	Listing of magnetic tape contents or file	Punched cards	35-mm microfilm	
Fixed-Ship Rawinsonde Data	All fixed ships	Observed	X			X	
Radiometersonde Data	Fixed ships (Rainier, Discoverer, & Rockaway only) and Island of Barbados (Paragon House)	Observed	X	X			
Boom Surface Meteorological Measurements	All fixed ships	Observed	X			X	
BOMEX Marine Meteorological Observations	All fixed ships	Observed	X	X			
Surface Pressure -- Marine Microbarograms	Oceanographer, Discoverer, Rainier, & Mt. Mitchell	Observed				X	
Fixed-Ship Operations Data	All fixed ships	Support	X			X	
BOMEX Fixed-Ship Event Log	All fixed ships	Support				X	
Discoverer Weather Radar Photographs	Fixed ship Discoverer	Observed				X	

Table 1-0. Contents of the BOMEX Temporary Archive
(continued)

Name of BOMEX data archive product	Name of BOMEX acquisition platform or location from which data were acquired	Observed data or support data for evaluating observed data	Available forms(s) of archive products				Remarks
			Magnetic tape	Listing of magnetic tape contents or file	Punched cards	35-mm micro-film	
Discoverer Weather Radar Log	Fixed ship Discoverer	Support				X	
Salinity/Temperature/ Depth Data (STD 8 sps)	Fixed ship Oceanographer & Discoverer	Observed	X	X			
STD Support Data	All fixed ships	Support		X (Listing of punched cards)	X		
Radio Transmission Log for Salinity, Temperature, Depth & Sound Velocity	All fixed ships	Observed				X	
Sea Surface Temperature	All fixed ships	Observed				X	
RFF Aircraft Meteorological and Renavigated Flight Track Data	RFF DC-6 (39C), DC-6 (40C), and DC-4 (82E) aircraft	Observed	X	X			
RFF Flight Folder	RFF DC-6 (39C), DC-6 (40C), and DC-4 (82E) aircraft	Support				X	

Table 1-0. Contents of the BOMEX Temporary Archive

(continued)

Name of BOMEX data archive product	Name of BOMEX acquisition platform or location from which data were acquired	Observed data or support data for evaluating observed data	Available forms(s) of archive products				Remarks
			Magnetic tape	Listing of magnetic tape contents or file	Punched cards	35-mm microfilm	
RFF Radar Photographs	RFF DC-6 (39C), DC-6 (40C), and DC-4 (82E) aircraft	Observed				X	
RFF Aircraft Cloud Photographs	RFF DC-6 (39C) & RFF DC-6 (40C) aircraft	Observed					Data available as duplicates of multiple 400-ft reels of color film & 800-ft reels of black and white film
RFF Photgraphic Quality Review Log	RFF DC-6 (39C), DC-6 (40C), and DC-4 (82E) aircraft	Support				X	
Navy and Air Force Aircraft RECCO Observations	Navy WC-121, AF WB-47, AF RB-57, and AF WC-130 aircraft	Observed	X	X			
Navy WC-121 Radar Photographs	Navy WC-121 aircraft	Observed				X	
Air Force WB-47 Radar Photographs	Air Force WB-47 aircraft	Observed				X	

Table 1-0. Contents of the BOMEX Temporary Archive (continued)

Name of BOMEX data archive product	Name of BOMEX acquisition platform or location from which data were acquired	Observed data or support data for evaluating observed data	Available forms(s) of archive products				Remarks
			Magnetic tape	Listing of magnetic tape contents or file	Punched cards	35-mm microfilm	
Air Force WC-130 Dropsonde Data	Air Force WC-130 aircraft	Observed	X	X			
U. S. Army Island Radar Photographs	Island of Barbados	Observed				X	
"Weather Radar Investigations on the BOMEX"	Island of Barbados	Support					Obtainable from Defense Documentation Center or National Technical Information Service
Island Rawinsonde	Paragon House, Island of Barbados	Observed					Available as hard copies of the Adiabatic Chart and Winds Aloft Computation Sheets for each sounding
Hughes ATS-3 Data (Period IV)	Paragon House, Island of Barbados	Observed					Available as duplicates of original negatives in positive form

1.0.0 BOMEX FIXED-SHIP DATA ACQUISITION

Five ships occupied fixed positions during the four BOMEX Observation Periods (table 1-1). For the Core Experiment, which covered Period I (May 1 through 15), Period II (May 24 through June 10), and Period III (June 19 through July 2), the U.S. Coast and Geodetic Survey* ships Rainier, Oceanographer, Mt. Mitchell, and Discoverer occupied positions ALFA, BRAVO, DELTA, and ECHO, respectively, at the corners of the BOMEX square, and the U.S. Coast Guard cutter Rockaway occupied position CHARLIE at the center of the fixed-ship array (fig. 1-1). For the Tropical Convection Program during Period IV (July 11 through 28), the five ships were stationed in a staggered pattern of fixed positions (fig. 1-2). Because some of the ships departed designated positions a day or two early and others occupied positions a day or two late owing to operational problems, the dates given above do not coincide exactly with the operations of each ship. A chronological listing of operations is given in table 1-2.

During all four periods, the fixed ships made sea-surface and oceanographic measurements and surface and upper air observations. Special instrumentation included: the signal conditioning and recording device (SCARD); rawinsondes to measure temperature, humidity, and pressure during their ascent and to provide tracking targets for wind direction and speed; radiometersondes to measure upward and downward radiation; a special boom extending from the bow of each ship and carrying instruments to measure dry-bulb, wet-bulb, and sea-surface temperature, relative humidity, wind speed and direction, and radiometers to measure incident, reflected, and total radiation; salinity/temperature/depth (STD) sensors; the boundary layer instrument package (BLIP), released from all ships except the Rockaway, suspended below a tethered balloon or parafoil kite, and carrying sensors to measure temperature, humidity, and horizontal and vertical wind speed. Basic observation systems aboard each fixed ship are identified in table 1-3.

Each ship was equipped with a free-fall, deep-sea mooring system to maintain its position. However, the Rainier's mooring system failed on May 1, the Mt. Mitchell's on May 3, the Rockaway's on May 25, and the Discoverer's and Oceanographer's on June 21. All wind speed and direction data acquired after mooring failure -- during periods of steaming and periods of drift -- must therefore be corrected for ship motion.

Observation systems were standardized for the fixed ships, with some variation in special instrumentation for the program to be served. Data were acquired in the form of analog magnetic-tape, strip-chart, punched paper-tape, manually logged, and photographic or filmed records.

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*Now the National Ocean Survey.

Table 1-1. Geographic positions of BOMEX fixed ships

Ship	Position	Latitude	Longitude
	Periods I, II, and III (square array)		
Rainier	ALFA (A)	16°50'N	59°12'W
Oceanographer	BRAVO (B)	17°36'N	54°34'W
Rockaway	CHARLIE (C)	15°00'N	56°30'W
Mt. Mitchell	DELTA (D)	12°23'N	58°23'W
Discoverer	ECHO (E)	13°08'N	53°51'W
	Period IV (staggered array)		
Rainier	BRAVO (B)	17°30'N	54°00'W
Rockaway	CHARLIE (C)	15°00'N	56°30'W
Discoverer	ECHO (E)	13°00'N	54°00'W
Mt. Mitchell	LIMA (L)	10°30'N	56°30'W
Oceanographer	GOLF (G)	7°30'N	52°42'W

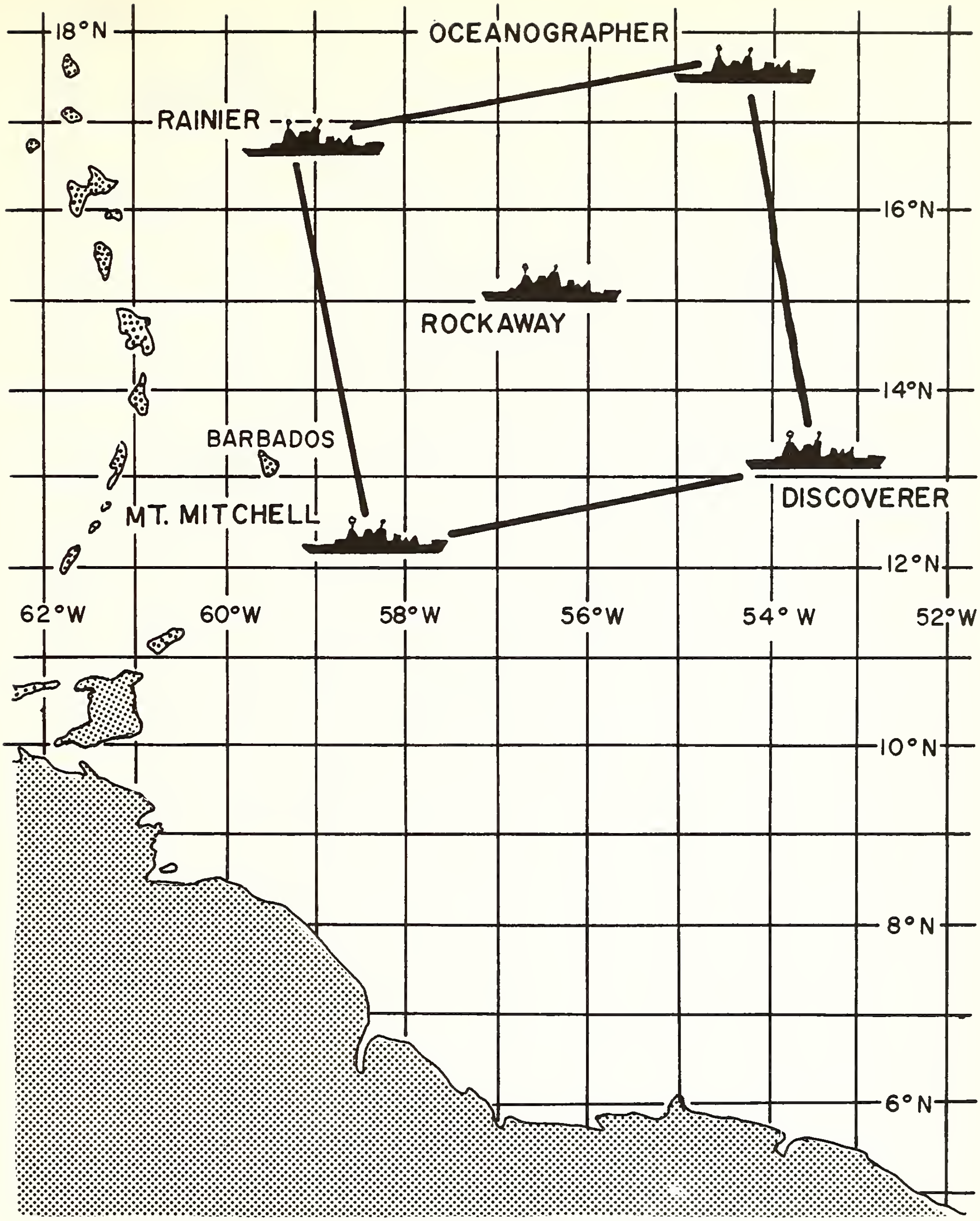

Figure 1-1. Fixed-ship array during Periods I,II, and III.

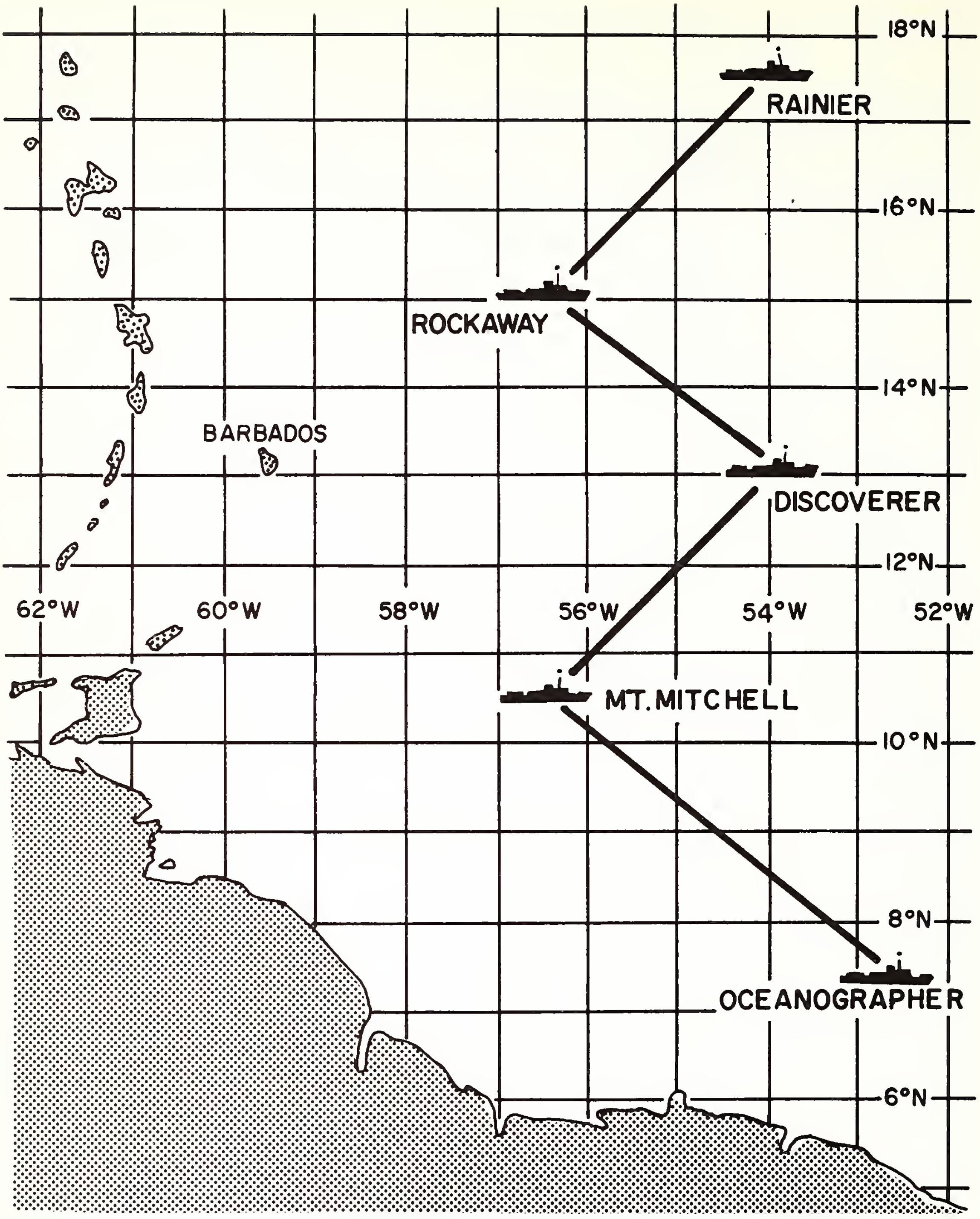

Figure 1-2. Fixed-ship array during Period IV.

Table 1-2. Chronology of ship operations during BOMEX

Date 1969	Ship activity*				
	Oceanographer	Discoverer	Mt. Mitchell	Rainier	Rockaway
April					
30	In port at Bridgetown	In port at Bridgetown	In port at Bridgetown	Arrived at Station "A"	En route to Station "C"
May					
1	En route to Station "B"	"	Arrived at Station "D"	Deep sea; moor. failed	Arrived at Station "C"
2	Arrived at Station "B"	"	Moored on Station "D"	On Station "A"	Moored on Station "C"
3	Moored on Station "B"	"	Deep sea; moor. failed	"	"
4	"	"	Medical evacuation to Bridgetown	"	"
5	"	"	On Station "D"	"	"
6	"	Arrived at Station "E" and moored	"	"	"
7	"	Moored on Station "E"	"	"	"
8	Moored on Station "B"; M&C Day	Moored on Station "E"; M&C Day	On Station "D";M&C Day	On Station "A"; M&C Day	Moored on Station "C"; M&C Day
9-14	Moored on Station "B"	Moored on Station "E"	On Station "D"	On Station "A"	Moored on Station "C"
15	Departed for Bridgetown	Departed for Bridgetown	Departed for Bridgetown	Departed for Bridgetown	Departed for Bridgetown

Table 1-2. Chronology of ship operations during BOMEX (continued)

Date 1969	Ship activity*				
	Oceanographer	Discoverer	Mt. Mitchell	Rainier	Rockaway
May 16	Arrived in Bridgetown	Arrived in Bridgetown	Arrived in Bridgetown	Arrived in Bridgetown	Arrived in Bridgetown
17-21	In port at Bridgetown	In port at Bridgetown	In port at Bridgetown	In port at Bridgetown	In port at Bridgetown
22	In port at Bridgetown	Departed Bridgetown for Station "E"	In port at Bridgetown	Departed Bridgetown for Station "A"	Departed Bridgetown
23	Departed Bridgetown	Arrived and moored on Station "E"	Departed Bridgetown	Arrived at Station "A"	Arrived and moored on Station "C"
24	Arrived and moored on Station "B"	Medical evacuation to Bridgetown	Arrived on Station "D"	On Station "A"	Moored on Station "C"
25	Moored on Station "B"	Arrived at Bridgetown; departed	On Station "D"	"	Deep sea; moor. failed
26	"	En route to Station "E"	"	"	On Station "C"
27	"	Arrived and moored on Station "E"	"	"	"
28	"	Moored on Station "E"	Departed for Bridgetown; returned to Station "D"	"	"
May 29 to June 9	Moored on Station "B"; 5/29 M&C Day	Moored on Station "E"; 5/29 M&C Day	On Station "E"; 5/29 M&C Day	On Station "A"; 5/29 M&C Day	On Station "C"' 5/29 M&C Day

Table 1-2. Chronology of ship operations during BOMEX (continued)

Date 1969	Ship activity* Oceanographer	Discoverer	Mt. Mitchell	Rainier	Rockaway
June					
10	Departed for Bridgetown	Departed for Bridgetown	Departed for Bridgetown	Departed for Bridgetown	Departed for Bridgetown
11	Arrived in Bridgetown	Arrived in Bridgetown	Arrived in Bridgetown	Arrived in Bridgetown	Arrived in Bridgetown
12-18	In port at Bridgetown	In port at Bridgetown	In port at Bridgetown	In port at Bridgetown	In port at Bridgetown
19	Departed Bridgetown	Departed Bridgetown	Departed Bridgetown	Departed Bridgetown	Departed Bridgetown
20	Moored on Station "B"	Moored on Station "E"	On Station "D"	On Station "A"	On Station "C"
21	Deep sea; moor. failed	Deep sea; moor. failed	"	"	"
22-25	On Station "B"	On Station "E"	"	"	"
26	"	"	Departed "D" to recover buoy, then returned	"	"
27	On Station "B"; M&C Day	On Station "E"; M&C Day	On Station "D"; M&C Day	On Station "A"; M&C Day	On Station "C"; M&C Day
28	On Station "B"	On Station "E"	On Station "D"	On Station "A"	On Station "C"
29	"	"	Departed "D" to recover BLIP, then returned	"	"
30	Departed "B" for Bridgetown	"	On Station "D"	"	Departed "C" for "B," arrived at "B"

Table 1-2. Chronology of ship operations during BOMEX (continued)

Date 1969	Ship activity*				
	Oceanographer	Discoverer	Mt. Mitchell	Rainier	Rockaway
July					
1	Arrived in Bridgetown	On Station "E"	On Station "D"	On Station "A"	On Station "B"
2	In port at Bridgetown	Departed for Bridgetown	Departed for Bridgetown	Departed for Bridgetown	Departed for Bridgetown
3	"	Arrived in Bridgetown	Arrived in Bridgetown	Arrived in Bridgetown	Arrived in Bridgetown
4-8	"	In port at Bridgetown	In port at Bridgetown	In port at Bridgetown	In port at Bridgetown
9	Departed Bridgetown for "G"	Departed Bridgetown for "E"	Departed Bridgetown for "D"	Departed Bridgetown for "B"	Departed Bridgetown for "C"
10	En route to Station "G"	Arrived at Station "E"	Arrived at Station "L"	En route to Station "B"	Arrived at Station "C"
11	"	On Station "E"	Departed for Bridgetown, then returned	Arrived at Station "B"	On Station "C"
12	Arrived at Station "G"	"	On Station "L"	On Station "B"	"
13-15	On Station "G"	"	"	"	"
16	On Station "G"; M&C Day	On Station "E"; M&C Day	On Station "L"; M&C Day	On Station "B"; M&C Day	On Station "C"; M&C Day
17-23	On Station "G"	On Station "E"	On Station "L"	On Station "B"	On Station "C"

Table 1-2. Chronology of ship operations during BOMEX (continued)

Date 1969	Ship activity*				
	Oceanographer	Discoverer	Mt. Mitchell	Rainier	Rockaway
July					
24	On Station "G"; M&C Day	On Station "E"; M&C Day	On Station "L"; M&C Day	On Station "B"; M&C Day	On Station "C"; M&C Day
25-27	On Station "G"	On Station "E"	On Station "L"	On Station "B"	On Station "C"
28	Departed for Bridgetown	Departed for Bridgetown	Departed for Bridgetown	Departed for Bridgetown	Departed for Bridgetown

* M&C Day — Maintenance and calibration day.

Table 1-3. Fixed-ship basic observation system

Ship	SCARD	Rawinsonde*	Boom**	STD	BLIP	SITS
Oceanographer	x	Scanwell WFSS	x	x	x	-
Rainier	x	Scanwell WFSS	(x)	x	-	-
Mt. Mitchell	x	Scanwell WFSS	x	x	x	-
Discoverer	x	Selenia radar	x	x	-	-
Rockaway	x	AN/SPS 29 radar	(x)	x	-	x

*Wind direction and speed acquired as slant range and azimuth.

**Parentheses indicate inclusion of instrumentation for radiation

SCARD (Signal Conditioning and Recording Device) was the primary recording unit aboard each of the fixed ships. Developed, operated, and maintained in the field by NASA's Mississippi Test Facility, it recorded on analog magnetic tape the main body of data derived from the observations. Exceptions were some manually recorded surface meteorological observations, punched paper-tape records of the Selenia radar rawinsonde positions, photographs of radar precipitation observations, STD strip charts, and analog strip-chart records of rawinsonde data that served as quality control.

1.1.0 FIXED-SHIP RAWINSONDE DATA (INCLUDING RADIOMETERSONDE DATA BOTH FROM THE SHIPS AND FROM ISLAND LOCATIONS)

1.1.1 Rawinsonde and Radiometersonde Instrumentation and Observation Procedures

Instrumentation. Rawinsonde balloons carried two instrument packages aloft for each observation: a temperature sonde equipped with a thermistor and a humidity sonde with a hygristor. All sondes and telemetry units were of standard National Weather Service type with these exceptions:

(a) Temperature sondes were specially wired to yield only signals for temperature, "low reference" (190 Hz), and a special midreference value (95 Hz) which replaced every fifth "low reference" in the sequence. This allowed more frequent reference signals and hence more precise corrections for variations in sonde characteristics -- enhancing accuracy. Selected precalibrated thermistors were used.

(b) Pressure sensors for temperature sondes were specially selected and precalibrated twice at the factory (once "up" and once "down," rejecting sensors that showed large differences) for better pressure accuracies.

(c) Humidity sondes were modified to yield an almost continuous humidity signal, interrupted only occasionally for a "low reference" signal. Because the humidity data are much less sensitive to minor sonde/battery variation than the temperature data, there was no need for frequent reference checks. A more sensitive uncalibrated pressure commutator was substituted for the usual baroswitch, to further shorten the time occupied by reference signals. All pressure data were taken from the temperature sonde and time-correlated to the humidity data. The net result was extraordinarily fine vertical resolution in the humidity profile.

Table 1-4 summarizes the instrumentation and sonde frequency used by each fixed ship during the four BOMEX periods. Temperature sonde and humidity sonde signal output was acquired by separate receivers aboard ship and recorded by SCARD, and on strip charts for quality control.

Two types of balloon-tracking systems were used: Scanwell Wind Finding at Sea System (WFSS) and radar wind finding system.

The *Oceanographer*, *Mt. Mitchell*, and *Rainier* carried the Scanwell WFSS. By means of rotary potentiometers mounted within the Scanwell balloon tracking instrumentation, continuous slant range and azimuth values of balloon position were acquired for the purpose of computing upper air wind directions and speeds. These data were recorded on SCARD and also on strip charts for quality control.

The *Discoverer* was equipped with Selenia radar, METEOR 200-RMT-2S (3.2-cm wavelength). Slant range and azimuth data, for computation of upper air winds, were recorded on punched paper tape at 15-sec intervals, with a printed paper tape for quality control.

Table 1-4. BOMEX rawinsonde instrumentation

Fixed ships	Period I	Period II	Period III	Period IV
Oceanographer *Mt. Mitchell* *Rainier**	Temperature 403/1680 MHz Humidity 72.2 MHz	Same as I	Same as I	Same as I
*Discoverer**	Temperature 403 MHz Humidity 403 MHz low level** FM sondes high level*** pulsed sondes	Same as I	Same as I	Same as I except all pulsed sondes used
*Rockaway**	Temperature 403 MHz Humidity 403 MHz low level** FM sondes high level*** pulsed sondes	Same as I	Same as I except all pulsed sondes used	Temperature 403 MHz Humidity 72.2 MHz

*Suomi-Kuhn 403-MHz FM-FM (upward and downward IR) radiometersondes flown at 0000 GMT daily.

**Planned termination at approximately 400 mb.

***From surface to burst.

The Rockaway used an AN/SPS-29 radar. Slant range and azimu ments were obtained visually by the radar operator at 1-min inter recorded manually for subsequent conversion to punched cards.

Radiometersonde observations were obtained at 0000 GMT each the Discoverer, Rainier, and Rockaway during all four BOMEX perio Suomi-Kuhn economical net radiometer to measure upward and downwa radiation was attached to the rawinsonde.

Observation Procedures. The procedures for making rawinsond tions were essentially the standard ones used by the National Wea An exception was that the frequency of observations, i.e., observ every 1 1/2 hours, required termination at 400 mb. The requireme increased accuracy and nearly continuous resolution in humidity d dictated the use during BOMEX of two sondes on the same balloon t that measured temperature only, the other humidity only.

The temperature sonde was not baselined because individually ted thermistors were used. Although there was no baseline check, standard preflight check and inspection were performed. The sond assembled in the normal fashion, except that no hygristor was ins After external checks of the instrument had been completed, the t sonde ground equipment was turned on and allowed to warm up and t activated batteries were placed in the sonde for a 2- to 3-min wa period. By alternate touching of the two test leads with a commo the low reference and midscale reference respectively were transm The low reference signal was maintained long enough to set the re ordinate 95.0. After the reference had been tested and set on th chart, the temperature singal was checked for proper or expected The sonde transmitter was adjusted to the desired frequency; alte flights were tuned to different frequencies to minimize possibili abandoned flight interfering with preflight operations for the ne tion. Under normal circumstances, the sonde transmitter was neve the limits of the equipment frequency range, since some latitude for post-release frequency drifts. With the external switching c and the test leads clipped off, the temperature sonde baroswitch to a position corresponding to the nearest 0.1 contact representi ambient pressure read on the ship's precision aneroid barometer. procedures used to set the baroswitch were those suggested in Fed Meteorological Handbook 3.

The humidity sonde was inspected and reference-checked in th way as the temperature sonde, and the transmitter was tuned to th frequency. Following this, baseline measurements were made in th baseline check box. The baseline wet-bulb and dry-bulb temperatu conditions were established to the nearest .1°C and the corespon relative humidity was determined. With the humidity stabilized a 35 percent (normally around 33 percent), the baseline conditions recorded on a special Rawinsonde Observation Form (BOMEX Card #0) in later data processing. The baseline measurements were conside for only 30 min. If release did not occur within 30 min, a fresh humidity element was installed and a new baseline check performed

the baseline check, the baroswitch was set. The humidity sonde baroswitch was set to either contact number 3 or 8, whichever was closest to the original pen arm position. Since the humidity sonde baroswitch was not used for pressure measurement, setting the baroswitch according to ambient station pressure was not required. Only the temperature sonde baroswitch was used for pressure measurements. Setting the pen arm as indicated ensured that relative humidity data were transmitted at release and a low reference shortly thereafter.

A 300-gm balloon was used for flights to 400 mb at the 1 1/2-hour release frequency. For all 0000 GMT observations and flights released at the 6-hour release frequency, a 600-gm balloon was used. With two instrumentation packages, the ascent rate was nominally 200 m/min for the 300-gm balloon and 300 m/min for the 600-gm balloon. During BOMEX Observation Period I (May 3 to May 15), the two sondes were strapped together (back to back), but signal interference between the two instruments occurred occasionally and such flights were not processed. Therefore, the sondes were separated on the train by 1 1/2 to 2 m, with the temperature sonde nearest the balloon. For flight, the arrangement was balloon, train regulator (15 to 20 m of line included), sondes spaced 1 1/2 to 2 m apart, 3 1/2 m of line, and target (for the Discoverer and Rockaway only).

Just before release, all ground equipment was rechecked and the SCARD operators were notified to prepare for release. Immediately before release, the humidity sonde external "low reference" wire was grounded to the sonde for at least 5 sec, and this connection was broken as the balloon was released. The resulting shift in signal frequency was used in later data reduction as indication of "lift-off."

After release, the usual procedures for monitoring rawinsonde ground equipment were followed, and the observation was terminated as scheduled or as soon as sonde failure occurred in flight.

The same preflight check and procedure used for the rawinsondes was used for radiometersonde observations. The radiometer was attached according to instructions given by Dr. P.M. Kuhn, Environmental Research Laboratories, NOAA, Boulder, Colorado 80302. Detailes concerning the radiometer, attachment to the sonde, and preflight check can be obtained from Dr. Kuhn.

1.1.2 Rawinsonde Data Processing

The rawinsonde data were processed by the National Aeronautics and Space Administration's Mississippi Test Facility (NASA/MTF) and the Slidell Computer Complex. After early review of the digitized SCARD analog data, it became evident to the BOMAP Office that, because of inconsistencies in observational techniques, operational difficulties, and other problems (such as digital noise), a comprehansive set of rawinsonde processing software could not be constructed without some intermediate processing step that would produce sufficiently complete output for review and for design of final rawinsonde processing software. The BOMEX Temporary Archive rawinsonde data are the output of this intermediate processing step and are called "A_o Rawinsonde Output." These data include the processed rawinsonde observations for all four BOMEX Observation Periods. The processing technique developed at MTF made it possible to retrieve a considerable amount of data that would have been judged unusable if one were to examine only the usual strip-chart recordings. Much of the noise that occasionally hides data on the strip charts was filtered out by the techniques described below.

The archive products consist of magnetic tapes and 35-mm microfilm, each containing all processed rawinsonde observations for one ship observation period, i.e., all rawinsonde data for one fixed ship for one BOMEX Observation Period. In either form, the data represent a time series of 5-sec data points (averaged over a 5-sec period) from launch to termination of processing. For the inventory of available data and instructions for ordering, see section 4.0.0, Data Ordering Instructions and Costs.

The "A_o" rawinsonde data processing is described in the sections that follow: 1.1.2.1 SCARD Analog Digitization; 1.1.2.2 Data Reduction Programs and Procedures (Including Examples of 35-mm Microfilm Output); 1.1.2.3 Computations Used in the "A_o" Rawinsonde Data Processing; 1.1.2.4 Manual Inputs and Preparation for Use in "A_o" Rawinsonde Data Processing; 1.1.2.5 Characteristics of the "A_o" Rawinsonde Data To Be Considered Before Use in Analysis; and 1.1.2.6 "A_o" Rawinsonde Data Archive Magnetic Tape Format.

1.1.2.1 SCARD Analog Digitization

Temperature- and humidity-sonde signals for all ships were recorded as frequency-modulated signals on SCARD. Slant range and azimuth from the Scanwell WFSS balloon-tracking equipment installed on the *Oceanographer*, *Mt. Mitchell*, and *Rainier* were also recorded on SCARD, but as amplitude-modulated signals. All these parameters were frequency-multiplexed on one of the seven SCARD recording channels. The temperature- and humidity-sonde input signals from ground-station receivers aboard the fixed ships were designed to vary between 10 and 200 Hz, but in many cases exceeded 200 Hz. The slant range and azimuth input voltages from the Scanwell WFSS varied between 0 and 5 v D.C. The slant range was a ramped signal representing successive 2,000-m increments of measured slant range. The azimuth input from Scanwell consisted of two inputs, one voltage (0 - 5 v D.C. ramp) representing the range from 0 to 360° (called AZ360), the other (0 - 5 v D.C. ramp) representing successive 0 to 20° ranges (called AZ20). These two azimuth voltages, derived from precision

potentiometers mounted within the Scanwell antenna servo-drive train, were necessary to achieve the appropriate resolution in measured azimuth. On the <u>Discoverer</u>, slant range and azimuth were acquired by a Selenia radar, Model METEOR 200 RMT-2S, at 15-sec intervals and recorded digitally on punched paper tape and on a hard-copy printout. On the <u>Rockaway</u>, slant range and azimuth were acquired by an AN/SPS-29 radar and recorded manually at 1-min intervals.

Digitization of the above signals required a two-pass operation: a <u>first pass</u> that converted the analog FM/FM (frequency modulated) and FM/PAM (pulse amplitude modulated) signals to digital form at 16 times real-time recording speed, resulting in 10 samples per second (10 sps) digital values of frequency and D.C. voltages; and a <u>second pass</u> that edited, formatted, scaled, and reduced the 10-sps digitized SCARD data to 2 sps and produced as output one reel of magnetic tape containing all measured frequency values and D.C. voltages gathered in one 24-hour period (0000 GMT through 2400 GMT) for one fixed ship. The <u>first pass</u> was made by an SDS 930 Automatic Telemetry Reduction System -- a program-controlled system in which an AMPEX FR-1400 analog tape unit, time-code-generator decoder, 18 discriminators, two cycle counters, input/output tie-in crossbar units, five levels of a priority interrupt system, three digital tape units, and other peripheral input/output devices were used. The <u>second pass</u> was made by an IBM 7094 program that created SDS 930-compatible 2-sps tape from a 10-sps tape. This equipment and the programs were operated and managed by the NASA Slidell Computer Complex, Slidell, La.

Conversion of the rawinsonde data through the <u>first pass</u> and <u>second pass</u> is described below.

<u>First pass digitization method used for temperature- and humidity-sonde data</u>

For each element, the demodulated output was input to a zero detection unit. At each positive-going crossover, the following took place:

(a) The appropriate counter was updated by one.

(b) The contents of a 312.5-kHz clock (recorded on SCARD as 3.125 kHz, then multiplied for system control) was transferred to the appropriate storage register. At the expiration of each 1/10 sec, the output for each element (temperature/temperature references or humidity/humidity references) was computed by $V = t/c$, where V = recorded value, t = the time (in units of 312.5-kHz clock), and (c) = the integral number of positive crossover. Thus, a time series of 10-sps values (one 10-sps series for the temperature sonde and one for the humidity sonde) were formed as input to the <u>second pass</u>. Each 10-sps time series contained measured temperature or humidity values and their respective reference values in the sequence of normal occurrences during the observation.

Second pass method used for temperature- and humidity-sonde data

The 10-sps samples were converted to Hz values for each 1/10 sec by dividing the output (v above) of digitizing into 3,125,000. Following conversion to Hz, a noise elimination averaging technique was applied to the 10-sps data within one 1/2-sec period (i.e., five 1/10-sec data points) to form the 2-sps time series. Selective averaging was accomplished by comparing the new arithmetic average of the input data set with the previously averaged point for this variable. If the difference between these two values exceeded the tolerance as specified on the noise tolerance manual input card to the second pass program ($\pm$ .5 Hz for temperature-sonde data and $\pm$ 1.0 Hz for humidity-sonde data), the point deviating most from the arithmetic mean was discarded, and the previous average was replaced with a new arithmetic mean of (n-1) 1/10-sec points. The process was then repeated until the correct tolerance was established or until only two points remained; the average of these two points was then accepted as the average for one 2-sps data point. Following averaging, the digitizing system calibrations were applied to the 2-sps data points.

First pass method used for slant range, azimuth 360, and azimuth 20

For each channel (one for slant range, one for azimuth 360, and one for azimuth 20), the signals were demodulated through a discriminator giving a D.C. voltage nominally in the range of $\pm$ 7.5 v. At the beginning and end of each SCARD tape, the calibration outputs were taken for each channel and recorded separately. Each 1/10 sec, the three discriminated voltage outputs were multiplexed to an analog-to-digital converter at the rate of 50 μsec per channel. The converter was capable of digitizing in the range of $\pm$ 10 v with significance to approximately 0.01 v. Thus, a slant range, azimuth 360, and azimuth 20 10-sps time series was formed for each variable for input to the second pass program.

Second pass method used for slant range, azimuth 360, and azimuth 20

The 1/10-sec values were scaled to 10,000 counts (where 0 - 5 v $\equiv$ 0 - 10,000 counts) as follows:

$$\text{Counts} = 10{,}000\ (A_t - L_c)\ /\ (H_c - L_c),$$

where L_c and H_c are low reference calibration and high reference calibration, respectively, as recorded on SCARD. The calibrations represented the average of the beginning and ending calibrations on one SCARD tape, and A_t is the variable sample. The 10-sps values were then reduced to 2-sps values by the noise elimination averaging used for rawinsonde temperature and humidity, with the tolerances for slant range and azimuth 360 being 60 counts and for azimuth 20 being 250 counts. At this point, the 2-sps time series of slant range, azimuth 360, and azimuth 20 were ready for the next stage of processing.

1.1.2.2 Data Reduction Programs and Procedures (Including Examples of 35-mm Microfilm Output)

The 2-sps digitized data base was used in processing and reduction of rawinsonde observations from voltages and frequency 2-sps samples to 5-sec averages of meteorological units. Only the steps involved in this processing are described here; computational details and manual inputs are discussed in sections 1.1.2.3 and 1.1.2.4, respectively.

The first step was to review the 2-sps tape for discrepancies in time (time of day, GMT) caused by malfunctions in the time code generator input recorded on SCARD analog tape or injected during the decoding and digitization of the analog signal. Such errors normally represented read-write errors as a shift of data within a record. This was done with a Tape Edit/Tape Copy procedure according to the following specifications, by which parity errors were also edited:

(1) When there were no parity errors during a read operation and time progressed by consistent time differences (deltas), the end product was a copy of the original tape.

(2) When a parity error was found, the record was skipped, "parity error" was printed out, and a total kept of how many there were on each 2-sps tape.

(3) When a sync error occurred, the record was skipped, "sync error" was printed out, and a record kept of how many sync errors occurred on the tape. A "sync error" was defined as follows:

(a) millisecond in real time work greater than 999,

(b) seconds greater than 86,399, and

(c) any bit greater than 11 in the flag word.

(4) When there was a gap in time (i.e., difference between successive time samples being different from the expected delta of .5 sec) - whether this gap was on the original 2-sps tape, was due to skipped record because of parity or sync error, or was deleted by the Tape Edit/Tape Copy procedure - the times before and after the gap and the time difference (delta) were printed out.

(5) Forward jumps in time (i.e., increasing time with a delta of more than .5 sec) with consistent time differences of .5 sec or more after the jump forward were kept. When followed by a backup in time so that the time sample going back in time when compared with the jump forward established a consistent delta from the sample preceding the forward jump, a forward jump was deleted.

(6) Time samples and the associated variable samples that progressed with inconsistent deltas were deleted by defining the time sample as a dead word. Each deleted time sample was printed out.

(7) All time backups were deleted although time progressed by consistent time differences from the sample that moved back in time.

Note: In "A_0" outputs, TG ("time gap") in the tabulated data indicates deletion of data by the Tape Edit/Tape Copy procedure.

From this point on in the processing of the "A_0" rawinsonde data, the "time-edited" 2-sps data and manually derived "processing" start time and stop time were used in data reduction, as follows:

(1) Five-second averages of the humidity- and temperature-sonde data were computed by a reference detection and noise elimination averaging technique similar to the one used in averaging 10-sps data to 2 sps (see sec. 1.1.2.1).

Note: No attempt was made to distinguish the radiometer signals in the 0000 GMT observations on the Discoverer, Rainier, or Rockaway.

(2) Thirty-second averages of slant range and 60-sec averages of azimuth each 30 sec were computed. Azimuth bias corrections were made at this point.

(3) A reference pattern check for data consistency was performed as follows:

(a) When four low references occurred between two midreferences, a normal pattern was defined.

(b) When three low references occurred between two midreferences, an additional low reference was inserted at the midpoint of the longest time period between successive midreferences.

(c) When eight low references occurred between two midreferences, a midreference was inserted between the fourth and fifth low references.

(d) Any other reference pattern resulted in termination of processing of this particular sounding.

The above steps resulted in a working tape that served as input to the next series of tasks by which the averaged data were adjusted or corrected:

(1) The 5-sec averaged raw frequencies for temperature were adjusted for midreference and low reference drift and converted to resistences.

(2) The 5-sec averaged raw frequencies for humidity were adjusted for low reference drift.

(3) Continuous 5-sec samples of temperature and humidity frequencies were obtained by linear interpolation over areas of data that were missing because of time gaps or by loss during the "noise elimination" averaging routine or during times of midreferences or low references.

At this point, the 5-sec temperature resistances (temperature in terms of resistance), humidity frequencies, the 30-sec averages of slant range, and two series of 60-sec azimuth averages were converted to scientific units of temperature, humidity (relative and specific), pressure, height, and wind components (U and V) at 5-sec intervals. Input calibration data required in addition to the 5-sec, 30-sec, and 60-sec averages discussed above were:

(1) Baseline data for the humidity sonde, release pressure contact number, and balloon size (300 or 600 gm) taken from the BOMEX Rawinsonde Observation Form (Card #0).

(2) Surface temperature, humidity, pressure, and wind direction and speed taken from the Surface Observation Form (Card #1). The observation selected for use as the surface condition was the observation closest to 45 min after release.

(3) Latitude and longitude of the ship taken from the Ship Operations Form (Card #4).

(4) Pressure contact table taken from the temperature-sonde baroswitch pressure-calibration chart.

(5) Azimuth and slant range data obtained by the Selenia radar on the Discoverer (recorded on punch paper tape) and by the AN/SPS-29 radar on the Rockaway (recorded manually).

Figure 1-3 is an example of the 35-km microfilm tabulation of the 5-sec rawinsonde data. Figure 1-4 shows graphically the 5-sec temperature and humidity data versus pressure, and figure 1-5 displays the U-component and V-component of the measured wind versus pressure, including a pressure-height curve.

SHIP D DAY 172 LAUNCH TIME 23 15 0 PROCESS DATE 072270

SERIAL NO 106760 BALLOON WT 6

RECORDED TIME HH MM SS	ELAPSED TIME SECS	TEMPERATURE DEG C	RELATIVE HUMIDITY PERCENT	PRESSURE MILLIBARS	HEIGHT METERS	SPECIFIC HUMIDITY G/KG	WIND COMPONENT W-E M/S	WIND COMPONENT S-N M/S
23 15 00	0	27.30	83.00	1018.30	8.23	18.608	-7.10	-1.25
23 15 05	5	27.71	75.18	1016.32	25.55	17.286	-7.74	-1.07
23 15 10	10	27.46	75.37	1014.34	42.89	17.107	-8.38	-.89
23 15 15	15	27.08	75.58	1012.36	60.25	16.810	-9.02	-.70
23 15 20	20	26.83	76.31	1010.38	77.63	16.757	-9.67	-.52
23 15 25	25	26.59	77.22	1008.20	96.84	16.755	-10.31	-.34
23 15 30	30	26.34	78.19	1005.53	120.31	16.763	-10.95	-.16
23 15 35	35	26.10	79.15	1002.87	143.84	16.769	-10.91	-.10
23 15 40	40	25.85	80.12	1000.20	167.40	16.772	-10.87	-.05
23 15 45	45	25.73	81.59	997.53	191.02	17.005	-10.84	.01
23 15 50	50	25.48	82.38	994.87	214.68	16.967	-10.80	.06
23 15 55	55	25.25	83.61	992.16	238.75	17.030	-10.76	.11
23 16 00	60	25.01	85.10	989.36	263.70	17.134	-10.73	.17
23 16 05	65	24.76	85.48	986.56	288.69	17.011	-10.78	.18
23 16 10	70	24.64	86.50	983.76	313.75	17.142	-10.84	.19
23 16 15	75	24.40	87.37	980.96	338.86	17.116	-10.89	.19
23 16 20	80	24.05	88.12	978.32	362.61	16.950	-10.95	.20
23 16 25	85	23.82	88.16	976.03	383.13	16.756	-11.01	.21
23 16 30	90	23.58	88.41	973.75	403.67	16.603	-11.06	.22
23 16 35	95	23.58	88.96	971.47	424.26	16.746	-11.16	.23
23 16 40	100	23.35	89.35	969.19	444.89	16.620	-11.25	.25
23 16 45	105	23.23	89.98	966.91	465.55	16.659	-11.35	.26
23 16 50	110	23.00	90.54	964.35	488.78	16.579	-11.44	.28
23 16 55	115	22.77	91.11	961.61	513.75	16.496	-11.53	.29
23 17 00	120	22.65	91.04	958.86	538.77	16.415	-11.63	.31
23 17 05	125	22.54	90.00	956.12	563.85	16.156	-11.66	.33
23 17 10	130	22.42	89.67	953.37	588.99	16.029	-11.70	.35
23 17 15	135	22.32	89.96	950.80	612.64	16.021	-11.74	.37
23 17 20	140	22.20	90.45	948.39	634.79	16.036	-11.77	.40
23 17 25	145	22.09	90.01	945.98	656.98	15.885	-11.81	.42
23 17 30	150	21.97	89.55	943.57	679.22	15.732	-11.84	.44
23 17 35	155	21.74	89.16	941.17	701.51	15.484	-11.77	.51
23 17 40	160	21.74	89.16	938.75	723.96	15.524	-11.69	.57
23 17 45	165	21.51	88.78	936.21	747.57	15.283	-11.62	.64
23 17 50	170	21.40	88.47	933.67	771.23	15.164	-11.54	.70
23 17 55	175	21.29	88.53	931.13	794.94	15.110	-11.46	.77
23 18 00	180	21.17	88.05	928.59	818.70	14.964	-11.39	.83
23 18 05	185	21.05	88.20	926.05	842.52	14.917	-11.24	.92
23 18 10	190	20.83	88.33	923.51	866.39	14.773	-11.10	1.01
23 18 15	195	20.60	88.46	921.29	887.31	14.626	-10.95	1.10
23 18 20	200	20.38	88.80	919.14	907.52	14.514	-10.80	1.19
23 18 25	205	20.15	89.73	917.00	927.75	14.498	-10.66	1.28
23 18 30	210	19.93	90.01	914.86	948.02	14.378	-10.51	1.37
23 18 35	215	19.71	90.49	912.71	968.32	14.287	-10.37	1.49
23 18 40	220	19.60	90.56	910.35	990.77	14.238	-10.22	1.61
23 18 45	225	19.27	91.17	907.09	1021.74	14.097	-10.08	1.73
23 18 50	230	19.06	90.87	903.84	1052.79	13.911	-9.93	1.85
23 18 55	235	18.95	91.26	900.58	1083.93	13.928	-9.79	1.98
23 19 00	240	18.73	91.31	897.32	1115.16	13.793	-9.64	2.10
23 19 05	245	18.62	90.89	894.60	1141.38	13.678	-9.52	2.27
23 19 10	250	18.51	88.92	891.93	1167.10	13.330	-9.39	2.44
23 19 15	255	18.41	87.84	889.27	1192.88	13.117	-9.26	2.60
23 19 20	260	18.30	86.76	886.60	1218.72	12.906	-9.14	2.77
23 19 25	265	18.19	86.30	883.98	1244.19	12.783	-9.01	2.94
23 19 30	270	18.08	85.57	881.43	1269.06	12.627	-8.88	3.11

Figure 1-3. Example of 35-mm microfilm tabulation of 5-sec rawinsonde data.

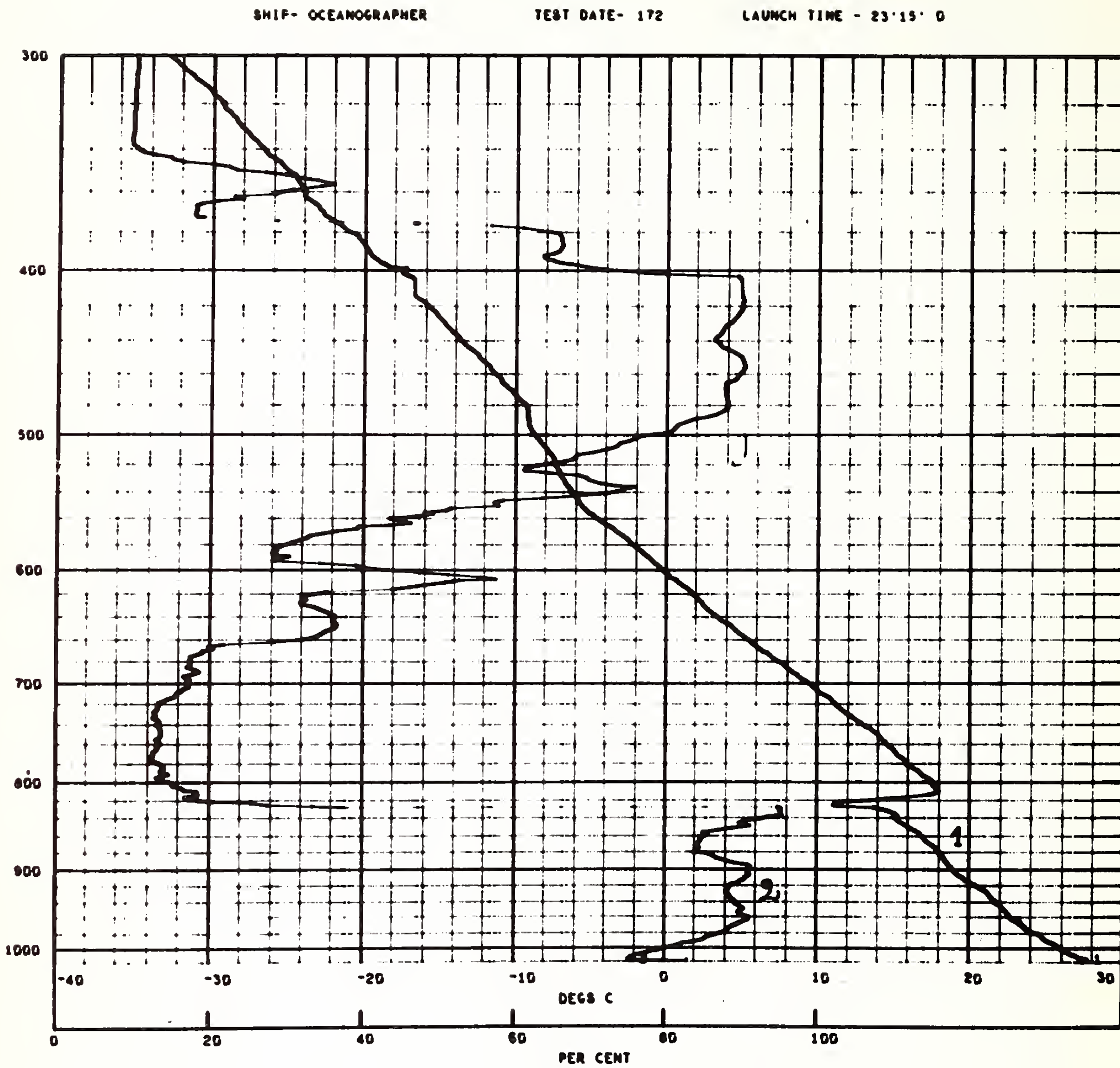

Figure 1-4. Five-second temperature and humidity data versus pressure.
1 - temperature; 2 - relative humidity.

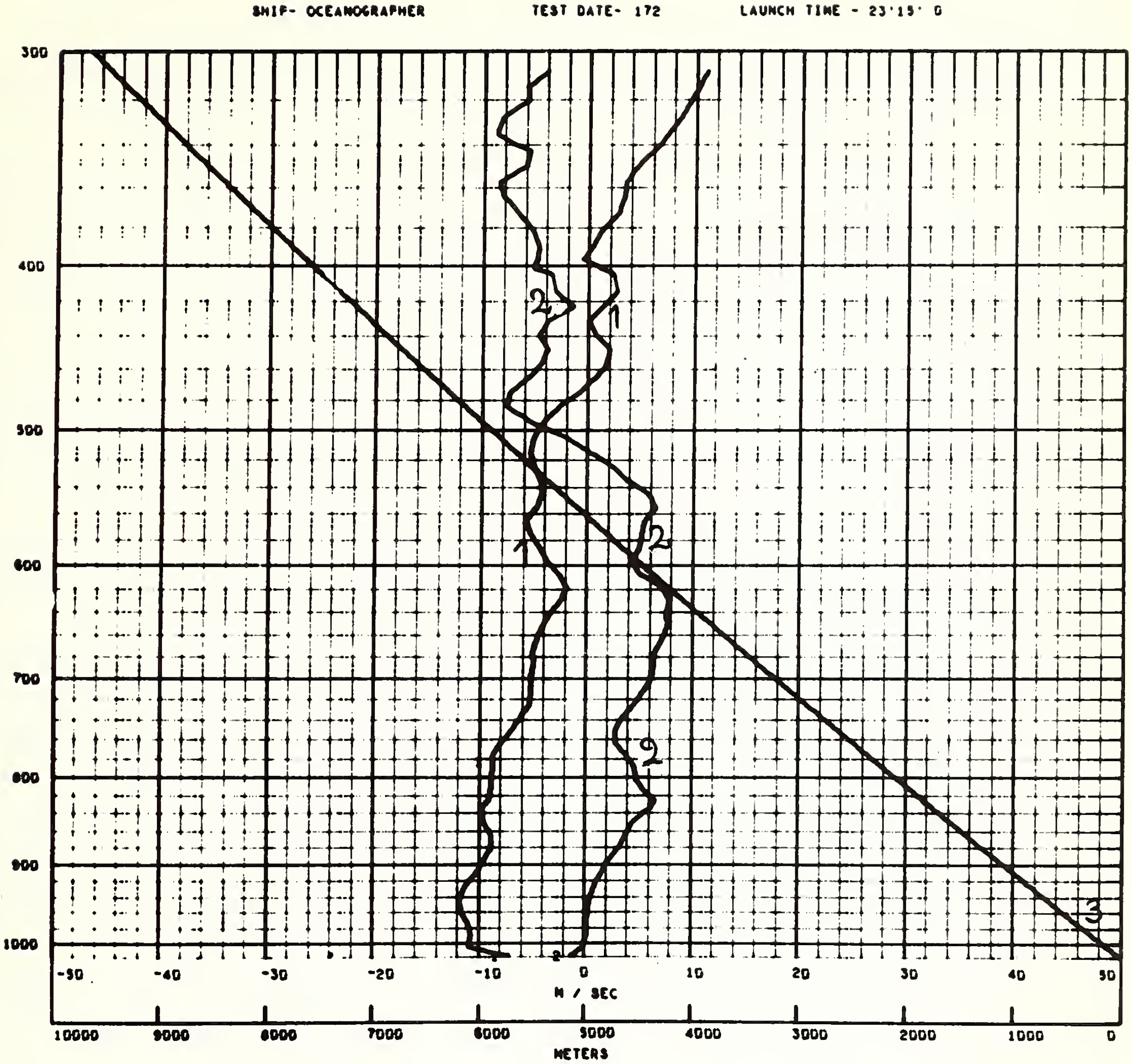

Figure 1-5. U and V components of measured wind versus pressure.
1 - W/E; 2 - S/N; 3 - height.

1.1.2.3 Computations Used in the "A_o" Rawinsonde Data Processing

The computations, signal detection techniques, and averaging techniques are discussed here in the order in which they were mentioned in the preceding section. The preparation of manual inputs will be discussed in section 1.1.2.4.

"Noise elimination averaging" of temperature and humidity 2-sps frequency values to form 5-sec averages and detection technique for separating temperature or humidity frequencies from the associated low and midreferences

Inputs for this operation consisted of ten 2-sps samples of temperature- or humidity-sonde values (containing both temperature or humidity frequencies and reference frequencies) making up a 5-sec time period for the average and the last available average for temperature or humidity, and the last average reference (midreference and low reference for temperature sonde; low reference only for humidity sonde). The sequence followed is described below.

(1) Temperature or humidity frequencies were separated from the reference values based on the following logic:

Let the absolute value of a 2-sps digital sample being considered equal X; then

(a) the sample was placed in the low-reference array if $X \geqslant 180.0$,

(b) the sample was placed in the midreference array if: *

during the first midreference after launch $85.0 \leqslant X \leqslant 101.0$,

during the second midreference after launch $(M_1 - 4.0) \leqslant X \leqslant (M_1 + 4.0)$,

during the third midreference after launch $(M_2 - 2.0) \leqslant X \leqslant (M_2 + 2.0)$,

during the fourth midreference after launch $(M_3 - 1.0) \leqslant X \leqslant (M_3 + 1.0)$, or

during the i^{th} midreference after launch $(M_{i-1} - 0.5) \leqslant X \leqslant (M_{i-1} + 0.5)$, where M = midreference value, and i = 5, 6, 7, . . . , n.

(c) If X met none of the above conditions, it was placed in temperature or humidity array.

*This step was not used in processing the humidity 2-sps data since no midreference occurred.

(2) When either the low reference or midreference arrays contained four or more detected 2-sps reference samples, the reference arrays were averaged first, then the temperature arrays. This was also the sequence for humidity data. Once an array had been selected for averaging, the arithmetic mean of the array was computed.

(3) The new average--the one computed in step (2) above--was intended to be compared with the previous average. However, because of the way in which entry was made to this subroutine, the new average was compared with either zero or a very large number, which forced the following logic to be applied:

(a) The 2-sps sample farthest from the new 5-sec average was eliminated. If this changed the value of the 5-sec average by less than 0.3 Hz for temperature or 1.0 Hz for humidity, the resulting average was accepted as the average for the 5-sec period. Otherwise the step was repeated.

(b) When all except one element were eliminated, a "dead word" (no data indicator) was reported as the average. This constituted a missing data point that was filled by linear interpolation between adjacent 5-sec samples for which an average other than dead words were reported.

Azimuth averaging and azimuth bias elimination

Azimuth measurements from the Scanwell WFSS on the Oceanographer, Mt. Mitchell, and Rainier were recorded from two potentiometers, one for the full range, 0 to 360°, and one for the 20° sector, constituting the coarse and fine azimuths, respectively. These two ranges were used to achieve the necessary resolution in azimuth for wind computations. The coarse azimuth was used in determining for which 20° sector the fine azimuth was valid and to estimate the azimuth bias error. The first step was to convert the azimuth 2-sps voltage values to degrees of azimuth, as follows:

$$CAZ = 0.36\ V_C,$$

$$FAZ = 0.002\ V_F,$$

where

CAZ = coarse azimuth (deg.),

FAZ = fine azimuth (deg.),

V_C = coarse azimuth voltage in voltage counts (0 - 10,000 counts $\cong$ 0 - 5 v D.C.), and

V_F = fine azimuth voltage in voltage counts.

If at some time, t, either a coarse azimuth or fine azimuth did not exist, there was no conversion to scientific units. In such instances, the 2-sps values were replaced by "dead words" (no data indicator) and not considered or used in any subsequent averaging. After conversion of CAZ and FAZ to degrees, the bias correction was applied. In practice, it was impossible to zero the two potentiometers measuring azimuth (CAZ and FAZ; FAZ = 0 or 20^{o} when CAZ = 0 or multiple of 20^{o}). Therefore, an adjustment for relative bias was necessary before combining the two azimuth readings into a measured azimuth value. The maximum relative bias tolerated was 10^{o} and included an allowance for backlash in the antenna drive gears to which the CAZ and FAZ potentiometers were attached. The azimuth bias routine was based on the assumption that the fine azimuth was correct and that the error was less than 10^{o}. The following Fortran routine was used to compute the measured azimuth from CAZ and FAZ and to apply bias correction:

```
          A = CAZ - FAZ
          IA = A/20
          A = A - 20 * IA
          IF (A-10) 2, 2, 1
    1     IA = IA + 1
    2     A = FAZ + 20 * IA
          IF (A-360) 4, 3, 3
    3     A = A - 360
    4     CONTINUE
```

As one can see, this method fails when the relative bias reaches 10^{o}. This happened occasionally and caused faulty azimuth values in the "A_o" wind computations.

Following the above manipulation of the 2-sps azimuth values, the resulting values were averaged to form two series of 60-sec averages of azimuth. In one, 60-sec averages were centered on the minute, and the other on the half-minute. These two series were used alternately in the wind computations.

Scanwell WFSS slant range processing technique

Slant range from the Scanwell WFSS on the Oceanographer, Rainier, and Mt. Mitchell was recorded as a ramped voltage, where 0 m = 0 v D.C. and 2,000 m = 5 v D.C. Thus, during any one observation, slant range measurements consisted of repeating voltages in the range of 0 to 5 v D.C. every 2,000 m of slant range. This field of digital voltages was first converted from 2-sps voltage "counts" to 2-sps slant range values in meters as follows:

$$S = 0.2\ v\ ,$$

where

S = slant range, in meters, modulo 2,000 m, and

v = voltage in counts.

Following conversion, 30-sec averages were calculated by the method described below.

(1) Five-second averages were formed from the 2-sps data and 30-sec averages were formed from the 5-sec averages. Displacement between each 5-sec average and the preceding 30-sec average was checked, with an acceleration of 20 to 25 m/sec/min allowed.

(2) After a 30-sec average had been obtained, the 5-sec averages contained in it were checked again, as in (1) above, but against the 30-sec average for these 5-sec data points rather than the preceding 30-sec average.

(3) Values were linearly interpolated for any missing 30-sec averages. If data for more than 3 min were missing, wind computations were terminated.

Adjustment of raw temperature 2-sps values for low-reference and midreference drift

Thermistor resistances at 30°C were individually measured by the manufacturer (Viz Mfg. Co.) and furnished to BOMEX, eliminating the need for a temperature baseline check. In addition, all thermistors were required to conform to a standard calibration curve with an RMS error of less than 0.1°. The low reference correction (a correction for nonstandard battery voltages) to temperature, humidity, and temperature-sonde midreference 5-sec average frequencies was as follows:

$$f = f_R * \frac{190}{f_{LR}} ,$$

where

f = corrected temperature, humidity, or temperature-sonde midreference 5-sec average frequency,

f_R = uncorrected temperature, or humidity, 5-sec average frequency, or temperature-sonde midreference 5-sec average,

f_{LR} = low reference, linearly interpolated in time between low-reference frequencies on either side of the f_R, and

$*$ = multiplication.

The internal resistances of the temperature sondes were computed from the midreference frequency obtained by switching a precision 50,000-ohm resistor into the circuit (every fifth reference contact being a midreference, the other four low reference). The internal resistance in ohms was calculated from

$$B = \frac{f_{ms} * 50{,}000}{190 - f_{ms}} - f_{ms},$$

where

B = internal resistance in ohms,

f_{ms} = midreference (midscale) frequency corrected for low-reference drift, as described above, and

* = multiplication.

With the above midreference correction, sensor frequency representing temperature in terms of resistance in ohms was calculated from

$$R = \frac{190 * (B + f)}{f} - (B + f) ,$$

where

R = sensor resistance in ohms representing measured temperature,

B = internal resistance in ohms,

f = temperature frequency corrected for low-reference drift, and

* = multiplication.

Calculations required to compute temperature (°C), humidity (relative and specific), pressure, height, and wind computations (U and V) at 5-sec intervals from temperature resistances (temperature in terms of resistance), humidity frequency, 60-sec azimuth values, and 30-sec slant range averages.

Conversion of thermistor resistance to temperature in degrees Celsius:

The temperature and thermistor resistances are related by the equation (furnished by Viz Mfg. Co.):

$$\log_{10} \frac{R}{R_{30}} = \sqrt{27.3710 + \frac{16{,}949.6}{t + 273.00}} - 9.12742,$$

where

R = thermistor resistance,

R_{30} = resistance of thermistor at $30^{o}C$, and

t = temperature in ^{o}C.

Solving for t, we have

$$t = \frac{16{,}949.6}{\left(9.12742 + \log_{10} \frac{R}{R_{30}}\right)^2 - 27.3710} - 273.0 \ .$$

Following this solution for t, a calibration correction was applied as shown in table 1-5.

Table 1-5 Calibration corrections for rawinsonde temperature (the manufacturer supplied the corrections based on actual tests with thermistor and hygristor used in the experiment)

Indicated temperature, t (^{o}C)	Correction, C (^{o}C)
30.00	+ 0.00
20.18	- .18
10.21	- .21
.18	- .18
- 19.92	- 0.08 (used as +0.08 for "A_o")
- 40.14	+ 0.14
- 60.07	+ 0.07
- 70.04	+ 0.04

Note: $t_c = t + C$, where t_c = corrected temperature 5-sec average (^{o}C), t = uncorrected temperature, and C = correction. For values of t not shown in the table, a correction was linearly interpolated.

Conversion of humidity 5-sec average frequencies to 5-sec humidity (relative and specific):

The first step was to convert the corrected humidity 5-sec average frequencies to humidity resistance values, as follows:

$$R = \frac{190 * (B + f)}{f} - (B + f) \ ,$$

where

R = sensor resistance in ohms,

B = 47,680 ohms (nominal internal resistance of the sonde),

f = 5-sec average frequency corrected for low-reference drift, and

$*$ = multiplication.

The resistance R as computed above is that of the hygristor and a 1.2×10^{o}-ohm resistor in parallel. Therefore, the hygristor resistance was calculated from

$$R_H = \frac{1.2 \times 10^6 * R}{1.2 \times 10^6 - R} ,$$

where R_H = hygristor resistance.

The resistance at 33 percent relative humidity, R_{33}, was determined by a baseline check prior to launch of the sonde. In the baseline check box, H_t was measured independently of the sonde from the wet-bulb and dry-bulb temperatures. If conditions were different from the standard 33 percent and 25°C, a correction was made by the equation (developed jointly by Viz Mfg. Co. and the BOMAP staff)

$$H_{25} \simeq H_t - \frac{C\ (H_t-33)\ (t-25)}{H_t} ,$$

where

H_t = relative humidity determined from dry- and wet-bulb readings,

H_{25} = H_t corrected to 25°C,

t = dry-bulb temperature in baseline box, °C, and

C = constant = 0.25 if $H_t > 33$ percent and 0.03 if $H_t < 33$ percent.

If the correction term was less than 0.5 percent (the usual case), H_{25} was assumed equal to H_t. Then H_{25} was substituted in the following equations (developed by the BOMAP staff):

$$A = \log_{10} \frac{RH}{R_{33}} = 4.733 - 2.500 \log_{10} (110 - H_{25}),$$

$$R_{33} = R_H/10^A ,$$

where

R_H = hygristor resistance, determined as above from humidity-signal baseline frequency, and

R_{33} = hygristor resistance at 33 percent relative humidity.

Relative humidity for 5-sec average frequencies during the sounding was computed by a three-step method:

Step 1

$$H_{25} = 110 - \text{antilog}_{10}\left(\frac{4.733 - \log_{10} \frac{R_H}{R_{33}}}{2.500} \right)$$

where

R_H = hygristor resistance at some temperature t, computed as above,

R_{33} = hygristor resistance at 33 percent (from baseline computation), and

H_{25} = relative humidity at 25°C.

Step 2

The relative humidity at temperature t was calculated from

$$H_t = H_{25} + \frac{C_1 \, (H_{25} - 33) \, (t - 25)}{H_{25}} ,$$

where

C_1 = 0.25 for H_{25} 33 percent,

C_1 = 0.30 for H_{25} 33 percent, and

H_t = measured relative humidity at ambient temperature t.

Step 3

Following this computation, a calibration correction was applied to H_t to obtain the corrected relative humidity. The calibration corrections are shown in table 1-6. Note that these particular corrections apply only for the computation of relative humidity as described above; they include both calibration corrections proper and corrections for errors in these simplified equations. The procedures described above are expected to give an RMS error of less than 3 percent relative humidity (not including errors due to hygristor exposure and thermal lag).

The procedure for computation of relative humidity was found to be unstable at low resistance values (i.e., low measured relative humidities). Thus the solution was limited at H_{25} equal the larger of (a) H_{25} computed as above or (b) 8.0-.1t, where t is the ambient temperature. Minimum values of relative humidity obtained by this scheme ranged from 2.2 percent at +20°C to 13.0 percent at -60°C. No insolation correction (due to radiation effects on the hygristor) or lag correction was applied to the relative humidity data.

Table 1-6. Calibration corrections for rawinsonde relative humidity (to be used only with BOMEX hygristor and BOMEX humidity equations)

Indicated relative humidity, H_t (percent)	Correction, C (percent)
14.5	- 4.5
24.5	- 4.5
27.0	- 1.0
31.8	+ 1.2
37.5	+ 2.5
46.1	+ 3.9
56.4	+ 3.6
68.3	+ 1.7
80.3	- 0.3
89.7	+ 0.3
95.0	+ 2.5
100.0	+ 0.0

Note: $H_c = H_t + C$, where H_c = corrected humidity, H_t = calculated humidity, and C = correction from above for a given H_t. (If H_t differed from the above, a correction was linearly interpolated.)

Computation of specific humidity was accomplished by

$$VP = 6.11 \frac{RH}{100} * 10^{C_3} ,$$

where

VP = vapor pressure 5-sec value,

RH = relative humidity 5-sec value,

$C_3 = \frac{a * t}{t + b}$,

t = temperature 5-sec value, ^{o}C,

a = 7.5,

b = 237.3, and

$*$ = multiplication.

Then,

$$q = .622 \frac{VP}{p - .378 * VP} ,$$

where

q = 5-sec specific humidity,

VP = vapor pressure, and

p = ambient pressure at the 5-sec point in question. (Pressure computation is discussed below.)

Computation of ambient pressure from temperature-sonde reference pattern:

Location of pressure reading in time was specified by references through the temperature-sonde baroswitch pressure-calibration table provided by the manufacturer. During reference detection, the time of reference occurrence was associated with the value of the reference. Baseline station pressure was entered at time zero.

The selection of the initial pressure contact for relating the references to the baroswitch pressure-calibration table was performed as follows.

(1) If the first reference encountered after launch was a midreference, it was contact #5 on the pressure-calibration table.

(2) If the second reference was a midreference, the first reference was #4.

(3) If the third reference was a low reference, the fourth a low reference, and the fifth a midreference, then the first contact after launch was #6.

No other conditions were tolerated, based on a review of all baroswitch calibrations and the range of surface pressure in the BOMEX observation area.

After the pressure equivalent of the first temperature-sonde reference after launch had been identified, the following edit was made by comparing the station pressure at launch with the pressure found at the first contact:

(1) If the station pressure was greater, the flight was computed normally.

(2) If the station pressure was equal to or less than the first reference pressure, then the flight was not processed when the difference was more than 2 mb or the time of recognition of the first reference was more than 15 sec after release. Otherwise, a new pressure was computed for the first contact by subtracting from the first contact pressure a factor that equaled twice the difference between the station pressure and the first contact pressure. Pressures at the 5-sec points were obtained by linear interpolation in this time-reference pressure field. No other changes or corrections were made to pressures from the baroswitch pressure-calibration table.

<u>Computation of layer thicknesses for altitude computations</u>:

The virtual temperature was calculated first; then the layer thickness was computed in geopotential meters as follows:

$$TV = T\ (1 + 0.61\ q),$$

where

TV = 5-sec virtual temperature (^{o}K),

T = ambient 5-sec temperature (^{o}K), and

q = 5-sec specific humidity (gm/kg);

$$DELH = 67.442\ \frac{TV_2 + TV_1}{2}\ \log_{10} \frac{P_1}{P_2}\ ,$$

where

P_1, TV_1 = pressure, virtual temperature at one 5-sec point, and

P_2, TV_2 = pressure, virtual temperature at the next 5-sec point; and

$$ALT_{P_2} = ALT_{P_1} + DELH\ ,$$

where

ALT_{P_2} = the altitude in geopotential meters at P_1, TV_2, and

ALT_{P_1} = the altitude at P_1, TV_1 in geopotential meters.

Computation of upper air winds:

Inputs to rawinsonde wind computations were slant range (30-sec averages), azimuth angle (two series of 60-sec averages, one for averages centered on the minute, one centered on the half-minute), altitude (from thickness computation and converted to geometric units), and surface wind (from Surface Observation Form, Card #1). These input parameters for the Oceanographer, Mt. Mitchell, and Rainier were processed to this point as described in the preceding paragraphs of this section.

The Discoverer used the selenia radar Model METEOR 200 RMT-2S for balloon tracking, with output consisting of printed and punched paper tape containing slant range, azimuth angle, and elevation angle at 15-sec intervals. The punched paper tape was converted to magnetic tape and a printout of the results prepared, which was scanned and compared with the printed paper tape. Observers' comments on the printed paper tape were used to edit the data. For instance, such a comment as "balloon lost" was used to delete bad data. After deletion from the magnetic tape of records proven to be bad, a computer edit of alternate 15-sec data points was performed as follows:

(1) The time difference between alternate samples was first edited for consistent changes (30-sec apart). "Dead words" or missing data indicators were inserted for unrecognizable or inconsistent times and the associated slant ranges and azimuths.

(2) For i = 30, 60, 90, , , n sec, successive second differences were computed for slant range or azimuth from $M = S_{t_i} - 2\ (S_{t_{i+1}}) + S_{t_{i+2}}$, where S_{t_i} = slant range or azimuth at time t_i.

(3) The following logic was used to edit the data:

(a) Until the first value of M less than 100, the value of S_{t_i} was replaced with a "dead word." After M of 100 was found, the value of S_{t_i} remained unchanged.

(b) After the first value of M less than 100 and whenever a value of M greater than 100 was detected, the value of $S_{t_{i+2}}$ was replaced with a "dead word."

(c) Whenever a "dead word" was encountered in S_{t_i}, $S_{t_{i+1}}$, or $S_{t_{i+2}}$, the value of M could not be computed and was irrelevant. The dead word was left in the table; condition 3(a) above was reverted to.

The results of this edit were values of slant range and azimuth sampled at 30-sec intervals and, depending on the edit, containing periods of time when no values existed for one or more 30-sec periods. No wind computations were made unless two or more consecutive 30-sec values of slant range and azimuth were found.

The Rockaway used an AN/SPS-29 radar for balloon tracking. Slant range and azimuth measurements were usually made at 1-min intervals and recorded manually on a BOMEX form. These data were then punched on cards directly from the form and transferred to magnetic tape. Since the measurements were made at 1-min, rather than 30-sec, intervals, linear interpolation was used to supply the intermediate 30-sec values of slant range and azimuth.

The slant range, azimuth angle, and altitude values described above for all fixed ships were used to compute horizontal distance out to the balloon and the S-N and W-E coordinates of that distance for each 30-sec point. At each 30-sec point, t, the 1-min movement from point t - 30 sec to t + 30 sec along each coordinate (divided by 60, giving units in meters per second) gave the zonal and meridional components at time t. Linear interpolation was used to derive components at 5-sec intervals.

The terms used in the computations are listed below and shown in figure 1-6 as related to wind computations.

HDO = horizontal distance out.

SLR = slant range.

GH = height of balloon.

H = height of ship's deck (release point).

CR = earth's radius = 6,375,000 m.

$\left.\begin{array}{l} R = 6337838 \\ SR = 6327368 \end{array}\right\}$ factors for relating geometric and geopotential height at 15°N.

AZ = azimuth angle.

$WWE_{(t)}$ = W-E wind component.

$WSN_{(t)}$ = S-N wind component.

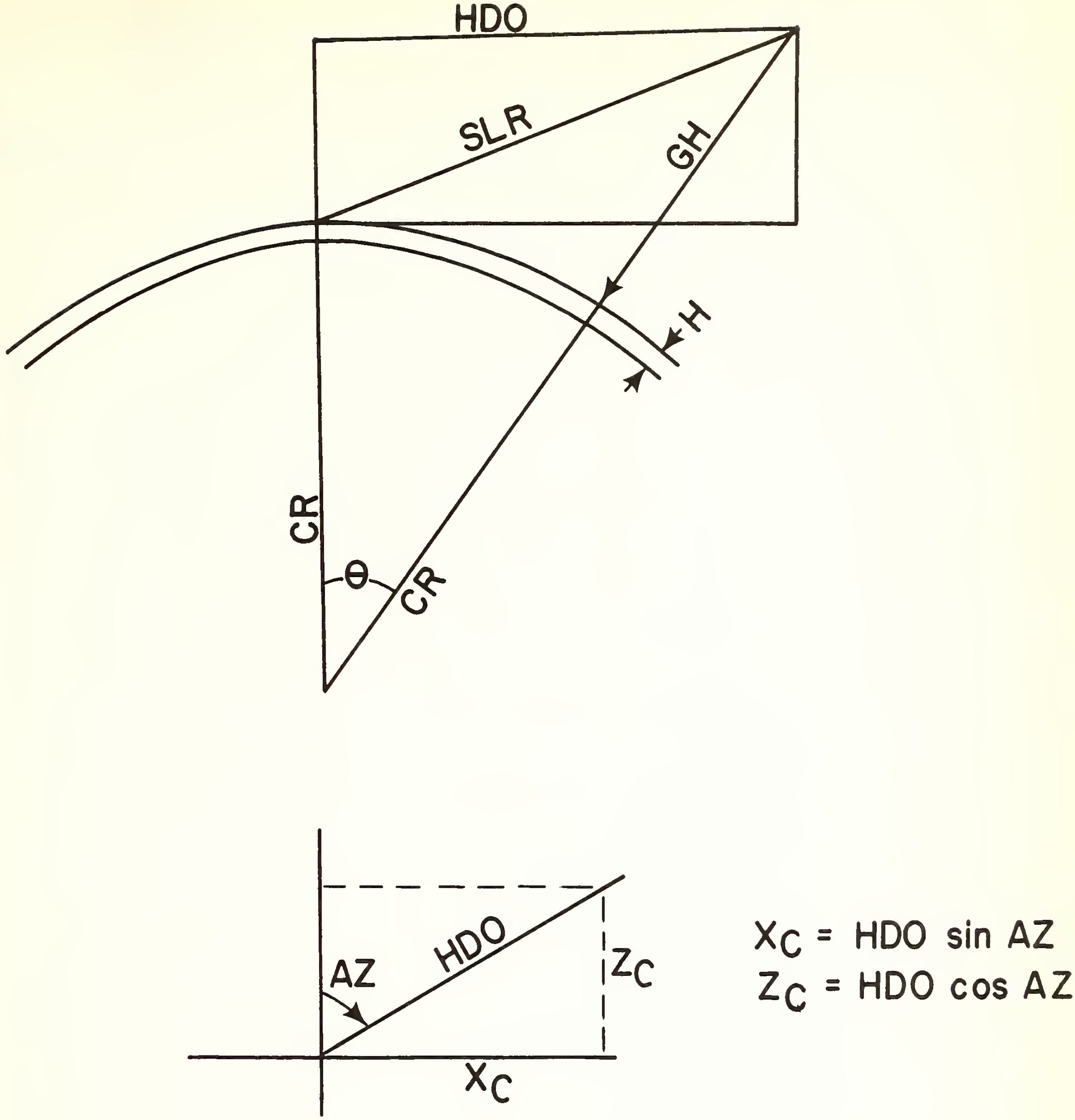

Figure 1-6. Diagram relating the terms used in wind computations.

The following equations were then used:

$$CRH = CR + H,$$

$$YS = CR + GH,$$

$$FXX = \left[\frac{CRH^2 + YS^2 - SLR^2}{2(CRH)\ (YS)}\right]^2,$$

$$\text{(Note: } FXX = \cos^2\theta)$$

$$0 = \tan^{-1}\sqrt{\frac{(1.0 - FXX)}{FXX}}$$

(Note: Numerator = $\sin^2\theta$; fraction = $\tan^2\theta$)

$$HDO = YS\ (\sin\theta),$$

$$X_C = HDO\ (\sin(AZ)),$$

$$Z_C = HDO\ (\cos(AZ)),$$

$$WWE_{(t)} = \frac{X_{C_{t+30}} - X_{C_{t-30}}}{60},$$

$$WSN_{(t)} = \frac{Z_{C_{t+30}} - Z_{C_{t-30}}}{60},$$

The following ship deck heights, H, were used:

Oceanographer	8.230 m
Rainier	9.144 m
Mt. Mitchell	9.144 m
Discoverer	6.706 m
Rockaway	7.010 m

1.1.2.4 Manual Inputs and Preparation for Use in "A_O" Rawinsonde Data Processing

Rawinsonde calibration data were entered manually on preprinted forms by shipboard personnel. The following titles and card numbers identify the types of data entered:

Rawinsonde Observation Form	Card code 0
Surface Observation Form	Card code 1
Ship Operations Form	Card code 4

These data sheets were punched on cards for use in machine reduction of rawinsonde observations. Before processing began, a procedure was devised that helped to verify the accuracy and consistency of the data. As a first step, data for each ship observation period were machine listed. Simple scanning of the columns on the listing dosclosed most of the punching errors, omissons, and duplications. Corrections to the cards were made and the data relisted.

An effort was then made to verify the accuracy of the card code 0 entries. A three-man team checked the data on the recorder strip charts, the card code forms, and the card code 0 machine listing for inconsistencies in the following entries:

Date/time of release.

Rawinsonde serial number (temperature sonde).

Thermistor serial number (resistance in ohms).

Precision aneroid pressure (station pressure).

Humidity baseline data--dry bulb, computed relative humidity, and humidity ordinate.

The actual baseline humidity traces on the recorder strip charts were examined at this time to ensure that the correct value had been read.

For reconciliation of any inconsistency noted, all other available entries were used. For example, when station pressure entries for an observation were inconsistent, the corresponding sea-level pressure entry on the Surface Observation Form and the preceding and following observations were checked to help establish the most reasonable value. Questionable rawinsonde serial numbers were corrected by examining the appropriate pressure-contact calibration chart, where both instrument number and release date/time were entered.

Errors in humidity baseline entries were corrected by using the set of values that resulted in the proper relationship between dry-bulb and wet-bulb depression, and relative humidity. Discrepancies in thermistor resistance entries were more difficult to correct as there was no other source to turn to for corroborative evidence. Inconsistencies of about 100 ohms or less were corrected by arbitrarily selecting the card code 0 entry as the proper value. Many larger inconsistencies were easily resolved since one of the entries was an obviously impossible value, beyond the limits of the "Table for Ordinate Setting on W/B Temperature Evaluator for Radiosonde." Some inconsistencies, however, could not be resolved because both values were reasonable. In these instances, the card code 0 entry was used in the "A_o" process but the observation was noted for future attention.

In order for computer operations to begin for the "A_o" and future processing, it was necessary to select, as accurately as possible the start time of each rawinsonde observation. Based on plots and listings of two-samples-per-second (2-sps) data, times were selected in hours, minutes, seconds, and milliseconds of what appeared to be the moment of release. Normally, the start time could easily be determined from the 2-sps data when a clearly defined transition from low reference to humidity at release was made. For some releases a zero-to-humidity or a low reference-to-temperature procedure was used. These also resulted in easily determined time data once a consistent pattern for a ship had been established.

Unfortunately, instances were noted where the above procedure was not followed or where noise or interference at release resulted in the loss of some definition. On these occasions the start time was classified as "indefinite." The best possible time estimate was made from records available in addition to the 2-sps plots and listings, such as 0 card entries of baroswitch setting and release contact, appearance of traces on the rawinsonde strip charts, time measurements of the interval between release contact and the first reference, etc. Whenever possible, start times were selected for all rawinsondes actually released regardless of whether usable data were recorded aloft.

Temperature stop time, which signaled the actual end of the sounding, was selected for each observation. Stop times were assigned only when there was no possibility of recovering data for a given flight beyond that time. Stop times for wind and/or humidity observations were assigned only if they preceded the temperature stop time.

1.1.2.5 Characteristics of the "A_O" Rawinsonde Data To Be Considered Before Use in Analysis

The following is to be noted regarding the "A_O" rawinsonde data:

(1) No lag corrections have been applied to the recorded temperature and humidity signals.

(2) Experiments have shown that, due to insolation and other effects, daytime humidities are recorded too low. Efforts to determine appropriate corrections are underway. The characteristics of this error are described in the following papers: Teweles, Sidney, "A Spurious Diurnal Variation in Radiosonde Humidity Records," Bulletin of the American Meteorological Society, September 1970; Morrissey, James F., and Frederick T. Brousaides, "Temperature-Induced Errors in the ML-476 Humidity Data," Journal of Applied Meteorology, October 1970; and Harney, Patrick J., "Differing Moisture Profiles in Radiosondings at Barbados," presented at the AGU/AMS meeting in Washington, D.C., in April 1970.

(3) Wind data were computed by a method analogous to that used for manual computations accomplished by Weather Bureau* observing personnel.

(4) Ship motion has not been added to wind data (see sec. 1.4.2).

(5) Interpolation over reference and data gaps in the record are linear.

(6) "A_O" programs could not detect radiometer data. When radiometers were flown on either temperature sonde or humidity sonde, radiometer signals were accepted as signals from the host sonde (0000 GMT soundings, Rainier, Discoverer, and Rockaway).

(7) No completely satisfactory procedure for unambiguously identifying all references was developed prior to the "A_O" processing. The greatest difficulty occurred during that portion of each flight when the temperature frequency curve passed through the point where a mid-reference was expected -- generally in the neighborhood of 400 mb. While a majority of these cases were handled properly, the pressure and/or temperature continuity for some flights was adversely affected.

(8) A characteristic of the humidity equipment (72-Mc ground equipment) was occasional "frequency doubling," for short periods of time, resulting in humidities evaluated too low by a factor of exactly 2.

(9) On some occasions (mostly during Observation Periods I and II) interference between the temperature and humidity signals, or from some other radio source, was observed, resulting in small shifts in one or the other.

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*Now National Weather Service.

(10) The baroswitch on the humidity sonde was designed to transmit reference signals only each fifth contact, and to transmit humidity signals at all other times. Occasionally small shifts in the received humidity signal were noted between those portions normally transmitting humidity and those normally transmitting the other four references.

(11) The pressure-contact relationship tables furnished to the computer during "A_o" processing were terminated at the 75th contact (approximately 300 mb). On a few occasions the entire table was recomputed because of a discrepancy in the contact-pressure relationship at release. In these cases, the "A_o" may have processed the flight to normal termination.

(12) Manually recorded surface pressure, temperature, and humidity data were used as the release data during the "A_o" process. The "surface pressure" used was station pressure at humidity-baseline time.

(13) The "A_o" programs were not designed to output any data if humidity signals (or humidity references) were missing.

(14) On some flights, the humidity reference signal was received below the reference detection threshold and was accepted as recorded humidity.

(15) On the Oceanographer during Periods I and II, portions of the record are affected by a capacitor on the slant range input to SCARD, resulting in nonlinear response. The slant range on the Mt. Mitchell was also occasionally interrupted by slippage of the gears, mostly during Period IV.

(16) The typical operator adjustment for reference drift to maintain the pen at ordinate 95 (190 cycles) did not affect the recorded signal. Occasionally, the true reference drifted above 200 cycles (ordinate 100), which was the cutoff for digitizing. These cases have been redigitized, but not reprocessed to develop "A_o" output.

(17) During processing, the proper sequence of four low references and one midreference was tested. If only one reference of a set was missed, it was inserted, but more than one caused termination of processing. In a few cases exactly five consecutive references (or six, causing one insertion) were lost, in which case processing continued but resulted in erroneous pressures and displacement of temperature and humidity data. (In case six references were lost, one was inserted, and the same procedure followed.)

(18) Plotting of the Rainier Observation Periods III and IV upper air wind data (U and V) has indicated a discrepancy of 30° to 40° when compared with the other fixed ships on a synoptic grid and with aircraft data. BOMAP is investigating the characteristics of this discrepancy.

(19) The Rockaway upper air wind data suffered from several serious deficiencies that compromised their resolution and accuracy.

(a) The balloon target could not be acquired before 6 to 10 min after launch.

(b) There was a positive bias of approximately 5,000 yards in all slant-range measurements. This was not discovered by BOMAP in time to be included in the "A_0" data-processing program without delaying it. Also the bias apparently increased (5,000 yards plus) as the experiment progressed.

(c) An automatic tracking aid was used by the radar observers in following the balloon radar target on the PPI. This had the effect of making the computed wind change at a uniform rate for periods of time up to several minutes; then the rate would abruptly switch to a new value. This completely masks any small wind shifts and displaces the location of apparent shear zones, generally upward. There is no way to correct this in processing the data.

(d) Slant range was recorded to the nearest 100 yards and azimuth to the nearest degree to conform to limits of resolution of the PPI display. This coarse resolution adds some random fluctuations to the apparent wind, which, however, do not mask the effect of the automatic tracking aid.

(e) A gross error in the radar synchroreceiver was detected on June 2, 1969, which affected all azimuth measurements from the radar. Failure date/time and degree of error is not known due to the nature of the failure.

1.1.2.6 "A_0" Rawinsonde Data Archive Magnetic Tape Format

Data from one ship for one BOMEX Phase (or Period) are on one magnetic tape. The first file on each tape contains card image records describing the data. In this file, the first record is "BOMEX A-ZERO RAWINSONDE DATA" (28 characters). The second record gives ship name, ship number, BOMEX Phase, and inclusive dates of observations. Example: "OCEANOGRAPHER, SHIP NUMBER Ø, PHASE III, JUNE 20 - JULY 3, JULIAN DAYS 171-184." The ship number is character 27; the Julian days are in characters 69-71 and 73-75. Additional records give details on format of data files.

The second and successive files contain data for one sounding each. One end-of-file mark separates adjacent files. There is a triple end-of-file mark after the last data file on each tape. The first record in each data file gives ship name and number, Julian day, nominal time of sounding in hours and minutes, actual release time of sonde in hours, minutes, and seconds, latitude in degrees and minutes, and longitude in degrees and minutes. The format is: H20, 4I10, 2F10.2. Example: OCEANOGRAPHER Ø 172 1313 131Ø15 . . . 17.36 . . . 54.34.

There are eight data words per scan and the format is: F10.0, F10.2, 6F10.1 (80 characters). Each record except the last contains 50 scans (4,000 characters). The last record will normally contain less than 50 scans.

Data elements are:

Scan Word	Data	Format
1	elapsed time from launch, hours, minutes, seconds	F10.0
2	temperature, degrees C	F10.2
3	relative humidity, percent	F10.1
4	pressure, millibars; pressure at time Ø is station pressure at baseline time	F10.1
5	height, meters; height at time Ø is barometer height	F10.1
6	specific humidity, grams/kilogram	F10.1
7	W-E wind component, meters per second	F10.1
8	S-N wind component, meters per second	F10.1

-9999. is used as a no-data indicator.

1.1.3 Radiometersonde Data Processing and Archive Magnetic Tape Format

Observations taken with Suomi-Kuhn 403-MHz, FM-FM, radiometers attached to the rawinsondes at 0000 GMT daily aboard the Discoverer, Rainier, and Rockaway were processed from strip-chart records by Dr. P. Kuhn, Environmental Research Laboratories, NOAA, Boulder, Colorado. The user is encouraged to contact Dr. Kuhn (telephone, FTS, 303-499-6208) concerning questions left unanswered by the brief description presented here.

1.1.3.1 Processing Procedures

Standard procedures were used for processing the temperature and humidity data from strip charts. The radiation values were used in two sets of computations. The first set consisted of computations that were made directly from the values read from the strip-chart records without adjustments and that included temperature readings from top and bottom plate sensors of the radiometer as well as air temperature values from the rawinsonde thermistor. The second set of computations consisted of a five-point polynomial fit to the radiation and cooling values only. It included a warming profile for the layer defined by the pressure preceding and following the cooling value, which, in effect, was a warming value, negative denoting cooling and positive denoting warming. Humidity values remained untouched since they were read at one point.

The data included in the temporary archive are in the form of punched-card images on magnetic tape and contain the following parameters:

Pressure, millibars.

Time from launch, minutes.

Ambient temperature, degrees C.

IR radiation upward, langleys/minute.

IR radiation downward, langleys/minute.

Net IR radiation, langleys/minute.

Warming, degrees C/day.

Mixing ratio, grams/kilogram.

Relative humidity, whole percent.

1.1.3.2 Radiometersonde Data Archive Magnetic Tape Format

The magnetic tape format consists of six separate files, of which the fifth one constitutes the radiometersonde data. When the radiometersonde data on magnetic tape are requested, all six files will be sent, not only the radiometersonde data. The six files of information on this tape are separated from each other by an end-of-file mark and followed by a double end-of-file. All information is in binary-coded-decimal (BCD) format, even parity, 800 bits per inch. The first file consists of 80-column card images, one card image per record, describing the formats of the data files. The other five files contain data that were either recorded manually or were read manually from strip-chart recordings; the data are in BCD card images, 50 cards (4,000 characters) per record.

The second file contains BOMEX Marine Meteorological Observations (see sec. 1.3.0); the third file contains Ship Operations Data (see sec. 1.4.0); the fourth file contains hand-tabulated STD Support Data (see sec. 1.7.3); the sixth file contains Dropsonde Data (see sec. 2.2.3).

The Radiometersonde Data, as noted above, constitute the fifth file. Each sounding is preceded by a header card with 1 in column 1 indicating beginning of the sounding. The header card gives ship's name and the date of the sounding. The data cards, where column 1 is the left blank, follow the header cards with data elements in the following order on each card:

Pressure, millibars.

Time from launch, minutes.

Temperature, degrees C.

IR radiation upward, langleys/minute.

IR radiation downward, langleys/minute.

Net IR radiation, langleys/minute.

Warming, degrees C/day.

Mixing ratio, grams/kilogram.

Relative humidity, whole percent.

The format is: 3F8.1, 3F8.4, F8.1, F8.3, I8.

1.2.0 BOOM SURFACE METEOROLOGICAL MEASUREMENTS

Surface meteorological observations included standard marine meteorological observations and measurements from instruments mounted on a boom fixed to and extending 10 m beyond the bow of each fixed ship; weather surveillance was provided by radar aboard the Discoverer. Also part of surface data acquisition, but not pertaining to meteorological parameters, were ship navigation data: true heading, speed relative to the water, and position. Included under the title Boom Surface Meteorological Measurements are the data from the instruments mounted on the boom, surface pressure from a capacitive-type barometer, and ship's heading from the gyro.

1.2.1 Instrumentation and Observation Procedure

Meteorological data obtained from the instruments mounted on the boom approximately 10 m above the sea surface were automatically recorded on SCARD at 30-sec intervals. Dry-bulb temperature, wet-bulb temperature, relative humidity, sea-surface temperature, wind speed, and wind direction were measured aboard all ships. In addition, boom instrumentation on the Discoverer, Rainier, and Rockaway included radiometers and pyranometers that yielded data on incident, reflected, and net radiation. Table 1-7 lists all parameters measured, identifies the sensors used for each measurement, and gives the output range for each.

Barometric pressure was also recorded automatically on SCARD. For these measurements, the Oceanographer, Rainier, Mt. Mitchell, and Rockaway used the Rosemount Engineering Company's capacitive pressure sensing unit, Model 1101-A33BADB (999.0 to 1,010 mb = 0 to 5 v D.C.). The Discoverer carried the NCAR DPD barometer, developed by the National Center for Atmospheric Research.

Ship's true heading was also recorded on SCARD from the output of a precision potentiometer mounted to a repeater which was slaved to the master gyro (0° to 360° = 0 to 5 v D.C.) on each of the fixed ships.

Since these boom, gyro, and barometric pressure measurements were recorded automatically on SCARD, no observing procedure was followed other than routine maintenance and calibration, which was usually performed daily for the boom sensors and during two of the four in-port periods for the ship's gyro and Rosemount barometer. The NCAR barometer was calibrated before the BOMEX field operations and after the barometer had been returned to NCAR. The calibration data derived from these tests have not been incorporated in the "A_0" processing of boom data. Calibration and intercomparison studies to provide final corrections to the boom, gyro, and barometric pressure measurements are underway at the BOMAP Office.

Table 1-7. Measurements from boom sensors

Measurement	Sensor	Remarks
Air dry-bulb temperature	Thermivolt thermometer, Model #752-10, Yellow Springs Instruments, Inc.	20°C to 35°C
Air wet-bulb temperature	Thermivolt thermometer, Model #752-10, Yellow Springs Instruments, Inc.	20°C to 35°C
Sea-surface temperature	Thermivolt thermometer, Model #752-10, Yellow Springs Instruments, Inc.	20°C to 35°C
Relative humidity	Relative humidity transducer, Model No. 15-7012, Hydrodynamics, Inc.	0.0% to 100%
Wind speed relative to ship	Wind speed transmitter, F420 series, U. S. Weather Bureau	0 mps to 30 mps
Incident solar radiation	Pyranometer, Model 15, Eppley Laboratory	Spectral range up to 2.5 μ
Incident terrestrial radiation	Pyranometer, Model 15, Eppley Laboratory	Spectral range up to 2.5 μ
Net total radiation	Suomi-Fransilla-Izlitser ventilated net radiometer	Spectral range 0.5 to 40 μ
Precipitation	Rain gage	Manually recorded

1.2.2 Boom Data Processing

The boom, gyro, and barometer data were processed by NASA/MTF, the products representing the output of an intermediate, "A_0," processing step (see discussion of rawinsonde data, sec. 1.1.2). These data, processed for all four BOMEX Observation Periods, are included in the BOMEX Temporary Archive.

The archive products consist of magnetic tapes or 35-mm microfilms containing daily tabulations of the boom parameters, ship's true heading, and barometric pressure for one ship observation period (i.e., all processed data for one fixed ship for one BOMEX Observation Period). In either form, the data represent 30-sec time series, 10-min averages, and 30-min averages (10-min and 30-min averages on microfilm only) for each BOMEX observation day. The inventory of available archive data products and instructions for ordering are contained in section 4.0.0, Data Ordering Instructions and Costs.

The documentation for "A_0" boom, gyro, and barometer data processing will be presented in the sections that follow: 1.2.2.1 SCARD Analog Digitization; 1.2.2.2 Data Reduction Programs and Procedures (including examples of 35-mm microfilm output); 1.2.2.3 Characteristics of the "A_0" Boom Surface Meteorological Measurements To Be Considered Before Use in Analysis; and 1.2.2.4 "A_0" Boom Surface Meteorological Data Archive Magnetic Tape Format.

1.2.2.1 SCARD Analog Digitization

The boom measurements, gyro heading, and barometric pressure were recorded on SCARD as voltage-modulated frequencies. The boom and gyro measurements were recorded as 30 commutated samples on one SCARD channel, i.e., each of these measurements were sampled for approximately 1 sec every 30 sec. Thus, two samples 750-800 msec in duration per minute were recorded on one of the seven SCARD channels. During BOMEX Observation Period I, barometric pressure was recorded the same way. After the first observation period, the barometer output was assigned a separate SCARD channel and recorded continuously because of multiplexer loading of the barometer. Digitization of the boom surface data required a two-pass processing procedure. A general description of the two-pass operation is given in section 1.1.2. The boom surface data digitization is discussed in detail below.

First-pass digitization method used for boom, ship's gyro, and barometer data. For each channel (one for all boom parameters, including gyro, and one for barometer), the signals were demodulated through a discriminator giving a D.C. voltage nominally in the range of ±7.5 v. At the beginning and end of each SCARD analog tape, the recorder channel calibrations were recorded separately. Each 1/10 sec, the two discriminated voltage outputs were multiplexed to an analog-to-digital converter at a rate of 50 μsec per channel. The converter was capable of digitizing in the range of ±10 v, with significance to approximately 0.01 v. Thus, a time series of 10-sps digital values for the boom parameters, gyro heading, and barometric pressure formed the input to the second-pass program.

Second-pass method used for boom parameters and gyro heading. Since the boom parameters and gyro heading were serially recorded as approximately 1-sec samples of each of the seven parameters (10 including radiation), and the sampling sequence was repeated every 30 sec, the first step was to separate the 10-sps samples for each parameter. Each parameter was recognized by the preassigned position of that parameter in relation to the reference pulse that initiated the start of a 30-sec sampling sequence. The position was defined as a change in voltage from a zero or base level. The number of changes in level defined a particular position. The sample time for each parameter was defined as the time at which the reference pulse occurred. Thus, individual parameters were actually acquired from 2 to 13 sec after the reference pulse.

Following separation, the 1/10-sec samples were scaled to voltage counts (where 0 - 5 v D.C. ≡ 0 - 10,000 voltage counts). After calibration had been applied as described in section 1.1.2, the four to seven 1/10-sec samples were averaged by the noise elimination averaging technique discussed in section 1.1.2 in connection with rawinsonde temperature and humidity. The noise tolerance limit was ± .05 v. The result of the 1/10-sec sample average was to form a time series of 30-sec readings for each parameter.

Second-pass method for Rosemount and NCAR DPD barometer. From the 1/10-sec time series, data were selected at 1/2-sec intervals to form a 2-sps time series of 1/10-sec samples. The 2-sps time series was scaled to counts as described above. Following this, sixty 1/2-sec values were averaged by the noise elimination averaging technique cited above; a tolerance of ±0.05 v was used.

1.2.2.2 Data Reduction Programs and Procedures

Following the Time Edit/Tape Copy procedure discussed in section 1.1.2, the 30-sec time series for each parameter was converted to scientific units. The transfer equations and constants used in converting measured voltages to scientific units for each fixed ship and BOMEX Observation Period are shown in table 1-8. At this stage, the wind direction was converted from measured relative wind direction to true wind direction by the inclusion of ship's heading.

For ship's gyro (true) heading, it was necessary to add a further correction because of voltage reduction at the sensing potentiometer by the SCARD recording electronics (a loading effect). This correction was applied to the gyro voltage before conversion to engineering units. The following equation* was used for the correction:

$$v = v_i \ (1.00000 + 5.10204 \times 10^{-10} \ [v_i \ (10{,}000 - v_i)]),$$

*This equation is an approximation. Its derivation will be given in a later publication.

where

v = corrected voltage in counts, and

v_i = recorded voltage in counts.

As the last step, 10-min and 30-min averages of the parameters were computed. Note that all 30-sec samples were processed, regardless of the operational status of the instrumentation, which means that data were processed from instruments that failed. No restrictive edit was performed on "A_o" boom data.

Figures 1-7, 1-8, and 1-9 show examples of the 35-mm microfilm listing of the boom 30-sec data, 10-min averages, and 30-min averages, respectively. In figures 1-8 and 1-9, the column entitled "Number 30-sec samples" shows the number of 30-sec samples used to form the 10-min and 30-min averages. All 10- and 30-min averages of wind direction and speed were formed as vector averages of the 30-sec wind speeds and directions.

1.2.2.3 <u>Characteristics of the "A_o" Boom Surface Meteorological Measurements To Be Considered Before Use in Analysis</u>.

For the fixed ship <u>Discoverer</u>, the transfer equation for the NCAR barometer used in "A_o" processing was wrong. The correct equation is as follows:

$$V = 0.149\ (P - 1000.5),$$

or

$$P = 6.72\ V + 1000.5,$$

$$P = 2000.75 - 0.968\ P_w,$$

where

V = NCAR barometer output in volts,
P = station pressure in millibars, and
P_w = incorrectly calculated pressure for processed "A_o" BOMEX NCAR DPD barometer data.

Other aspects of the Boom Surface Meteorological Measurements to be noted by the user are:

(1) All barometric pressures represent station pressures calculated at the barometers' heights shown in table 1-9.

(2) As noted previously, the "A_o" processing included all data. Periods of equipment failure and/or inoperative conditions are not indicated. For instance, <u>Rockaway's</u> Rosemount barometer failed early in the first period and was not repaired until Period II.

Table 1-8. Transfer equations and constants for conversion of measured voltage to scientific units

Ship	Temperature (DB), °C	Temperature (WB), °C	Temperature (sea sfc), °C
	$T = k_1V + k_2$ or $T = k_1cts/2000 + k_2$	$T = k_1V + k_2$ or $T = k_1cts/2000 + k_2$	$T = k_1V + k_2$ or $T = k_1cts/2000 + k_2$
	PERIOD I		
Oceanographer	T = .00140 (cts) + 14.9°	T = .00140 (cts) + 14.9°	T = .00140 (cts) + 14.9°
Rainier	T = .00140 (cts) + 15.0°	T = .00140 (cts) + 15.0°	T = .00140 (cts) + 15.0°
Mt. Mitchell*	T = .00140 (cts) + 15.0°	T = .00140 (cts) + 14.9°	T = .00140 (cts) + 15.0°
Discoverer	T = .00140 (cts) + 15.0°	T = .00140 (cts) + 15.0°	T = .00140 (cts) + 15.0°
Rockaway	(did not work)	(did not work)	(did not work)
	*Mt. Mitchell changed k_2 to 20° during the first period.		
	PERIOD II		
Oceanographer	T = .00140 (cts) + 20.0°	T = .00140 (cts) + 20.0°	T = .00140 (cts) + 20.0°
Rainier	T = .00140 (cts) + 20.0°	T = .00140 (cts) + 20.0°	T = .00140 (cts) + 20.0°
Mt. Mitchell	T = .00140 (cts) + 20.0°	T = .00140 (cts) + 20.0°	T = .00140 (cts) + 20.0°
Discoverer	T = .00140 (cts) + 20.0°	T = .00140 (cts) + 20.0°	T = .00140 (cts) + 20.0°
Rockaway	T = .00140 (cts) + 20.0°	T = .00140 (cts) + 20.0°	T = .00140 (cts) + 20.0°
	PERIOD III		
	All ships same as in Period II.		
	PERIOD IV		
	All ships same as in Period II.		

Table 1-8. Transfer equations and constants for conversion of measured voltage to scientific units (continued)

Ship	$WS = k_1(cts)/2000+k_2$	$WD = k_1(cts)/2000+k_2$	$G = k_1(cts)/2000+k_2$
		PERIOD I	
Oceanographer	WS = .002522(cts)+1.03m/s	WD = -.036(cts)+167°	G = .036(cts)+0°
Rainier	WS = .002510(cts)+1.03m/s	WD = -.036(cts)+162°	G = .036(cts)+0°
Mt. Mitchell	WS = .002466(cts)+1.03m/s	WD = -.036(cts)+162°	G = .036(cts)+280°
Discoverer	WS = .002476(cts)+1.03m/s	WD = -.036(cts)+179°	G = .036(cts)+0°
Rockaway	(did not work)	(did not work)	G = .036(cts)+0°
		PERIOD II	
Oceanographer	WS = .02522(cts)+1.03m/s	WD = -.036(cts)+167°	G = .036(cts)+5°
Rainier	WS = .002510(cts)+1.03m/s	WD = -.036(cts)+167°	G = .035(cts)+0°
Mt. Mitchell	WS = .002466(cts)+1.03m/s	WD = -.036(cts)+162°	G = .036(cts)+290°
Discoverer	WS = .002476(cts)+1.03m/s	WD = -.036(cts)+179°	G = .036(cts)+0°
Rockaway	(did not work)	WD = -.036(cts)+167°	G = .036(cts)+0°
		PERIOD III	
Oceanographer	WS = .002522(cts)+1.03m/s	WD = -.036(cts)+167°	G = .036(cts)+5°
Rainier	WS = .002510(cts)+1.03m/s	WD = -.036(cts)+167°	G = .036(cts)+0°
Mt. Mitchell	WS = .002466(cts)+1.03m/s	WD = -.036(cts)+162°	G = .036(cts)+290°
Discoverer	WS = .002476(cts)+1.03m/s	WD = -.036(cts)+179°	G = .036(cts)+0°
Rockaway	WS = .004375(cts)+2.00kts	WD = -.036(cts)+167°	G = .036(cts)+0°
		PERIOD IV	
	All ships same as in Period III.		

Table 1-8. Transfer equations and constants for conversion of measured voltage to scientific units (continued)

Ship	Relative humidity, %	Rosemount pressure, mb
	$RH = k_1V + k_2$ or $RH = k_1(cts)/2000 + k_2$	$PR = k_1V + k_2$ or $PR = k_1(cts)/2000 + k_2$
	PERIOD I	
Oceanographer	RH = .01 (cts) + 0	PR = .003400 (cts) + 999.0 mb
Rainier	RH = .01 (cts) + 0	PR = .003350 (cts) + 1001.5 mb
Mt. Mitchell	RH = .01 (cts) + 0	PR = .003400 (cts) + 999.0 mb
Discoverer	RH = .01 (cts) + 0	PR = .003400 (cts) + 996.0 mb PR = -.003475 (cts) + 1033.0 mb (NCAR)
Rockaway	(did not work)	(did not work)
	PERIOD II	
Oceanographer	RH = .01 (cts) + 0	PR = .003400 (cts) + 999.0 mb
Rainier	RH = .01 (cts) + 0	PR = .003400 (cts) + 999.0 mb
Mt. Mitchell	RH = .01 (cts) + 0	PR = .003400 (cts) + 999.0 mb
Discoverer	RH = .01 (cts) + 0	PR = -.0034748 (cts) + 1033.0 mb (NCAR)
Rockaway	RH = .01 (cts) + 0	PR = .003400 (cts) + 999.0 mb
	PERIOD III	
	All ships same as in Period II	
	PERIOD IV	
	All ships same as in Period II	

Table 1-8. Transfer equations and constants for conversion of measured voltage to scientific units (continued)

Ship	Radiometer (incident) langleys/min	Radiometer (reflected) langleys/min	Radiometer (net) langleys/min
	PERIOD I		
Rainier	RI = 0.00013335 (cts) + 0	RR = 0.00006935 (cts) + 0	RN = 0.00024390 (cts) + 0
Discoverer	RI = 0.00013830 (cts) + 0	RR = 0.00006545 (cts) + 0	RN = 0.00025000 (cts) + 0
Rockaway	RI = 0.00022990 (cts) + 0	RR = 0.00012315 (cts) + 0	RN = 0.00024390 (cts) + 0
	PERIOD II		
Rainier	RI = 0.00020000 (cts) + 0	RR = 0.00006935 (cts) + 0	RN = 0.00024390 (cts) + 0
Discoverer	RI = 0.00020745 (cts) + 0	RR = 0.00006545 (cts) + 0	RN = 0.00012500 (cts) + 0
Rockaway	RI = 0.00022990 (cts) + 0	RR = 0.00012315 (cts) + 0	RN = 0.00012195 (cts) + 0
	PERIOD III		
Rainier	RI = 0.00020000 (cts) + 0	(did not work)	RN = 0.00024390 (cts) + 0
Discoverer	RI = 0.00020745 (cts) + 0	RR = 0.00006545 (cts) + 0	RN = 0.00012500 (cts) + 0
Rockaway	RI = 0.00022990 (cts) + 0	RR = 0.00012315 (cts) + 0	RN = 0.00012195 (cts) + 0
	PERIOD IV		
	All ships same as Period II except that for the Discoverer, RI = 0.00019635 (cts) + 0 beginning on day 203 at 1800 GMT.		

SHIP G DAY 172 BOOM 30-SECOND DATA PROCESS DATE 071779

RECORDED TIME HH MM SS	DRY BULB DEG C	WET BULB DEG C	SEA TEMP DEG C	WIND SPD M/S	WIND DIR DEG	SHIP GYRO DEG	REL HUM PCT	AMB PRESS MBARS
23 00 43	27.03	24.93	26.93	7.73	87.4	88.2	81.5	1018.07
23 01 13	27.02	25.01	26.96	7.55	88.7	82.2	81.7	1018.07
23 01 43	27.04	25.07	26.96	7.64	102.2	81.2	81.8	1018.07
23 02 13	27.03	25.04	26.99	7.01	85.6	79.4	81.7	1018.07
23 02 43	27.06	25.13	26.99	6.99	89.3	81.1	82.7	1018.07
23 03 13	27.02	25.11	26.96	7.43	82.6	79.4	82.2	1018.09
23 03 43	26.87	25.13	26.91	8.54	75.4	74.9	82.4	1018.09
23 04 13	26.95	24.98	26.92	7.78	79.6	74.6	81.5	1018.09
23 04 43	26.95	24.98	26.88	8.78	86.9	75.9	81.6	1018.09
23 05 13	26.94	24.88	26.88	8.22	80.5	76.7	81.5	1018.11
23 05 43	27.04	25.12	26.91	8.39	76.2	81.9	82.0	1018.11
23 06 13	26.99	24.87	26.90	8.17	71.2	86.9	81.4	1018.09
23 06 43	26.96	24.86	26.90	7.95	74.4	96.9	80.9	1018.07
23 07 13	27.11	25.17	26.96	7.20	74.0	104.6	82.2	1018.05
23 07 43	26.99	25.06	26.96	8.04	73.3	105.2	82.4	1018.07
23 08 13	26.98	25.03	26.95	7.67	80.7	104.5	82.2	1018.07
23 08 43	27.00	25.22	26.99	8.54	83.4	99.1	82.5	1018.07
23 09 13	27.01	25.17	27.01	8.32	79.2	93.3	82.7	1018.09
23 09 43	27.02	25.17	26.96	7.69	76.8	91.9	82.8	1018.09
23 10 13	26.99	25.15	26.99	7.43	76.0	91.2	83.3	1018.07
23 10 43	26.95	25.11	26.94	7.54	71.4	94.3	83.3	1018.07
23 11 13	26.93	25.00	26.89	8.16	82.3	97.1	81.9	1018.07
23 11 43	26.98	24.99	26.95	7.97	83.4	100.8	81.4	1018.05
23 12 13	27.01	24.97	26.98	8.23	77.9	103.8	81.7	1018.02
23 12 43	27.05	24.95	27.03	9.05	76.5	105.1	81.8	1018.02
23 13 13	27.02	25.06	27.02	7.44	70.0	108.8	82.5	1018.02
23 13 43	27.04	25.04	27.05	8.53	71.8	110.1	81.9	1018.00
23 14 13	27.04	25.04	27.05	8.46	71.6	110.8	81.4	1018.02
23 14 43	27.04	24.98	26.95	8.87	70.8	109.9	81.4	1018.05
23 15 13	27.04	24.98	27.06	8.69	73.2	107.2	81.5	1018.05
23 15 43	27.02	24.95	27.07	8.89	76.0	104.0	81.2	1018.09
23 16 13	27.10	25.06	27.08	7.89	72.1	98.7	81.8	1018.11
23 16 43	27.15	25.20	27.10	6.94	101.9	93.7	82.7	1018.16
23 17 13	27.10	25.22	27.04	8.54	78.5	83.9	82.4	1018.18
23 17 43	27.06	25.08	26.98	8.69	75.9	81.2	82.2	1018.16
23 18 13	27.06	25.18	27.06	7.88	88.9	78.4	81.8	1018.16
23 18 43	27.06	24.99	27.04	8.24	91.6	80.5	81.3	1018.16
23 19 13	27.08	25.09	27.05	7.91	85.2	79.8	81.5	1018.18
23 19 43	27.20	25.24	27.10	6.88	85.3	77.8	82.6	1018.18
23 20 13	27.08	25.10	27.08	8.17	81.5	73.5	81.5	1018.16
23 20 43	27.13	25.09	27.09	7.95	93.6	72.2	81.5	1018.16
23 21 13	27.19	25.27	27.20	7.99	90.7	69.4	82.6	1018.16
23 21 43	27.07	25.08	27.10	7.71	82.2	68.5	81.4	1018.16
23 22 13	27.13	24.94	27.06	8.88	89.1	67.4	80.7	1018.18
23 22 43	27.26	25.10	27.14	7.89	94.0	65.4	81.0	1018.18
23 23 13	27.24	25.16	27.16	8.71	93.8	63.8	81.1	1018.18
23 23 43	27.27	25.14	27.18	7.94	91.7	66.1	81.2	1018.20
23 24 13	27.15	25.07	27.11	9.34	90.7	70.3	80.7	1018.22
23 24 43	27.23	25.00	27.13	9.32	93.8	78.0	80.4	1018.22
23 25 13	27.27	25.00	27.23	8.96	100.8	85.7	80.5	1018.24
23 25 43	27.21	25.10	27.20	9.71	88.6	87.4	80.6	1018.27
23 26 13	27.24	25.07	27.17	7.85	91.4	83.8	80.5	1018.27
23 26 43	27.24	25.20	27.21	8.50	73.6	78.5	81.5	1018.27
23 27 13	27.25	25.23	27.22	7.66	88.1	71.7	81.8	1018.24
23 27 43	27.15	25.23	27.17	8.21	77.4	64.1	81.5	1018.24
23 28 13	27.16	25.07	27.14	9.93	86.7	58.5	80.3	1018.18

Figure 1-7. Example of 35-mm microfilm listing of boom 30-sec data.

SHIP 0	DAY 173		BOOM 10-MINUTE AVERAGES				PROCESS DATE 071770		
ENDING TIME HH MM SS	DRY BULB DEG C	WET BULB DEG C	SEA TEMP DEG C	WIND SPD M/S	WIND DIR DEG	SHIP GYRO DEG	REL HUM PCT	AMB PRESS MBARS	NUMBER 30-SEC SAMPLES
00 09 43	27.18	25.02	27.15	9.57	85.5	102.7	80.0	1018.26	20
00 19 43	26.96	24.84	26.90	9.84	92.6	73.6	80.1	1018.33	20
00 29 43	27.04	24.73	27.01	8.56	90.4	91.6	78.9	1018.37	20
00 39 43	27.05	24.90	27.02	9.12	94.0	92.2	79.7	1018.37	20
00 49 43	26.99	24.97	26.96	9.26	91.8	92.9	81.1	1018.46	20
00 59 43	26.96	24.91	26.94	8.73	83.8	93.4	81.1	1018.45	20
01 09 43	26.92	24.77	27.54	8.92	88.5	92.5	80.0	1018.47	20
01 19 43	26.77	24.81	27.61	9.12	89.7	93.2	81.2	1018.51	20
01 29 43	26.73	25.03	27.58	8.27	84.4	89.8	84.4	1018.52	20
01 39 43	26.93	24.95	27.56	8.69	91.4	92.2	82.3	1018.55	20
01 49 43	27.13	24.91	27.56	9.80	84.5	92.4	79.9	1018.65	20
01 59 43	27.13	24.90	27.54	9.60	88.0	93.0	79.5	1018.69	20
** ** **	- TIME GAP -								
02 39 43	26.94	24.70	27.53	10.23	80.8	82.2	79.8	1018.44	5
02 49 43	26.95	24.61	27.50	10.18	85.6	78.7	78.4	1018.41	20
02 59 43	26.90	24.62	27.44	10.53	81.2	81.5	78.6	1018.30	20
03 09 43	26.84	24.72	27.46	9.88	83.0	85.4	79.5	1018.24	20
03 19 43	26.92	24.64	27.47	9.96	81.6	87.6	78.7	1018.24	20
03 29 43	26.92	24.73	27.49	9.81	79.1	87.2	79.6	1018.12	20
03 39 43	26.91	24.55	27.51	10.12	80.3	94.4	78.4	1017.93	20
03 49 43	26.96	24.62	27.49	10.44	71.2	134.0	78.2	1017.66	20
03 59 43	26.96	24.52	27.43	10.03	84.5	87.3	77.6	1017.73	20
04 09 43	26.88	24.67	27.50	9.40	81.1	89.0	79.2	1017.61	20
04 19 43	26.89	24.57	27.48	10.06	82.5	86.8	78.8	1017.49	20
04 29 43	26.88	24.59	27.47	9.73	77.1	95.1	78.7	1017.37	20
04 39 43	26.85	24.41	27.44	9.31	79.7	97.1	77.5	1017.26	20
04 49 43	26.83	24.57	27.48	8.84	82.3	87.9	78.7	1017.18	20
04 59 43	26.81	24.54	27.48	8.82	72.5	92.7	78.6	1017.10	20
05 09 43	26.76	24.45	27.47	9.24	73.2	89.7	78.3	1017.07	20
05 19 43	26.75	24.62	27.47	9.04	74.2	90.1	79.8	1016.97	20
05 29 43	26.83	24.80	27.48	8.71	80.3	89.5	81.0	1016.88	20
05 39 43	26.88	24.75	27.45	9.25	80.4	87.6	80.3	1016.77	20
05 49 43	26.86	24.39	27.46	9.00	78.2	89.5	77.0	1016.69	20
05 59 43	26.82	24.63	27.48	8.40	72.3	91.3	79.4	1016.63	20
06 09 43	26.78	24.67	27.47	8.59	73.3	88.7	80.2	1016.64	20
06 19 43	26.77	24.59	27.46	8.83	71.3	88.9	79.7	1016.66	20
06 29 43	26.76	24.64	27.46	9.35	69.5	90.3	79.9	1016.65	20
06 39 43	26.76	24.60	27.45	9.33	76.3	91.7	79.8	1016.59	20
06 49 43	26.72	24.53	27.42	9.19	80.7	88.6	79.5	1016.53	20
06 59 43	26.68	24.57	27.46	8.89	73.2	90.5	80.2	1016.48	20
07 09 43	26.69	24.53	27.44	9.46	77.4	88.4	79.9	1016.41	20
07 19 43	26.73	24.57	27.41	9.81	84.1	88.6	79.8	1016.47	20
07 29 43	26.71	24.53	27.45	9.58	74.0	99.9	79.7	1016.43	20
07 39 43	26.74	24.60	27.42	10.02	67.5	102.6	79.9	1016.45	20
07 49 43	26.77	24.57	27.43	9.93	77.3	89.5	79.6	1016.62	20
07 59 43	26.84	24.57	27.39	10.08	83.7	88.8	78.7	1016.67	20
08 09 43	26.87	24.66	27.42	9.72	80.1	90.4	79.4	1016.66	20
08 19 43	26.80	24.75	27.40	9.72	73.9	90.1	80.6	1016.67	20
08 29 43	26.80	24.64	27.42	9.34	79.4	89.7	79.8	1016.72	20
08 39 43	26.85	24.56	27.40	9.15	84.1	86.2	78.8	1016.82	20
08 49 43	26.83	24.55	27.33	9.75	90.8	79.4	78.7	1016.83	20
08 59 43	26.83	24.61	27.43	9.52	85.3	92.7	79.2	1016.94	20
09 09 43	26.87	24.50	27.40	9.22	86.4	93.7	78.2	1016.97	20
09 19 43	26.87	24.31	27.40	9.80	83.3	111.5	76.5	1016.99	20
09 29 43	26.85	24.33	27.38	9.76	84.5	110.1	76.7	1017.17	20
09 39 43	26.88	24.28	27.30	9.69	81.2	114.3	76.0	1017.27	20

Figure 1-8. Example of 35-mm microfilm listing of boom 10-min averages.

SHIP 0 DAY 172 BOOM 10-MINUTE AVERAGES PROCESS DATE 071770

ENDING TIME HH MM SS	DRY BULB DEG C	WET BULB DEG C	SEA TEMP DEG C	WIND SPD M/S	WIND DIR DEG	SHIP GYRO DEG	REL HUM PCT	AMB PRESS MBARS	NUMBER 30-SEC SAMPLES
21 01 43	27.44	24.80	27.11	10.18	80.6	172.3	75.7	1016.77	20
21 11 43	27.46	24.68	27.36	9.95	81.2	175.6	74.9	1016.82	20
21 21 43	27.40	24.82	27.32	9.69	77.6	169.7	76.3	1016.89	18
21 31 43	27.35	24.83	27.22	8.30	89.7	98.2	76.6	1017.24	20
21 41 43	27.33	24.86	27.24	8.94	81.0	91.4	77.3	1017.30	20
21 51 43	27.16	24.81	26.99	9.37	76.5	105.3	77.6	1017.39	20
22 01 43	27.03	24.93	27.01	9.53	89.0	11.1	79.9	1017.64	20
22 11 43	27.11	24.99	27.01	9.92	89.5	34.1	79.7	1017.81	20
22 21 43	26.65	24.67	26.60	8.37	70.3	139.2	81.4	1017.87	20
22 31 43	26.99	24.85	26.93	9.41	84.7	139.0	80.7	1017.81	20
22 41 43	27.01	24.89	26.93	9.26	83.4	111.0	80.1	1017.94	20
22 51 43	26.96	25.03	26.92	8.74	77.1	149.4	82.0	1017.87	20
23 01 43	26.98	24.97	26.93	8.25	78.4	103.9	81.6	1018.00	19
23 11 43	26.99	25.06	26.94	7.86	79.1	89.5	82.1	1018.08	20
23 21 43	27.08	25.08	27.06	8.06	80.4	90.9	81.8	1018.11	20
23 31 43	27.24	25.01	27.17	9.32	90.8	68.2	80.1	1018.20	20
23 41 43	27.34	25.03	27.31	9.12	84.1	107.6	78.7	1018.17	20
23 51 43	27.25	25.05	27.24	9.52	77.7	116.5	79.7	1018.11	20
00 01 43	27.22	25.02	27.22	10.03	74.1	126.7	79.6	1018.03	17

Figure 1-8. Example of 35-mm microfilm listing of boom 10-min averages (continued)

SHIP G DAY 172 BOOM 30-MINUTE AVERAGES PROCESS DATE 071770

ENDING TIME HH MM SS	DRY BULB DEG C	WET BULB DEG C	SEA TEMP DEG C	WIND SPD M/S	WIND DIR DEG	SHIP GYRO DEG	REL HUM PCT	AMB PRESS MBARS	NUMBER 30-SEC SAMPLES
23 30 00	27.08	25.05	27.67	7.67	90.5	128.8	79.6	1018.22	16
00 00 00	27.13	24.95	27.67	7.56	98.8	92.2	78.1	1018.44	60
00 30 00	26.96	24.99	27.65	7.36	89.8	110.8	79.8	1018.63	60
01 00 00	26.93	25.08	27.66	7.64	90.5	10[illegible].2	81.8	1018.83	60
01 30 00	27.01	25.04	27.65	7.87	95.8	101.6	80.1	1019.01	59
02 00 00	26.93	25.06	27.64	8.44	100.6	109.8	81.2	1019.03	60
** ** **	- TIME GAP -								
03 00 00	26.98	25.04	27.61	8.34	98.6	108.8	80.5	1018.52	42
03 30 00	26.98	25.04	27.60	8.41	97.4	116.3	80.5	1018.32	60
04 00 00	26.95	25.06	27.60	8.35	95.3	117.3	81.1	1018.00	60
04 30 00	26.90	25.12	27.58	8.65	103.2	90.3	82.1	1017.62	60
05 00 00	26.87	25.13	27.57	8.72	102.5	95.9	82.3	1017.28	60
05 30 00	26.82	25.17	27.58	7.85	101.4	113.0	83.6	1016.83	60
06 00 00	26.04	24.66	27.56	9.57	97.2	130.8	84.9	1016.47	60
06 30 00	24.76	24.31	27.53	11.07	114.7	90.1	93.8	1016.47	60
07 00 00	25.66	24.73	27.52	7.92	104.4	104.5	94.1	1016.53	60
07 30 00	25.04	24.46	27.51	9.13	101.7	90.3	93.2	1016.61	60
08 00 00	26.55	24.84	27.51	9.15	101.1	120.1	86.2	1016.42	60
08 30 00	27.06	24.97	27.51	9.94	101.5	110.0	81.6	1016.49	60
09 00 00	26.89	24.95	27.52	10.21	92.4	115.4	82.4	1016.75	60
09 30 00	26.92	24.74	27.49	10.91	101.5	103.0	80.6	1017.42	60
10 00 00	27.17	24.69	27.49	10.67	106.8	109.3	77.2	1017.82	60
10 30 00	27.27	24.60	27.47	10.59	107.4	108.2	75.6	1018.01	59
11 00 00	27.36	24.65	27.51	10.36	106.6	118.0	74.7	1018.17	60
11 30 00	27.31	24.65	27.53	10.41	100.9	120.9	74.9	1018.52	60
12 00 00	27.20	24.77	27.52	9.63	96.9	115.9	76.9	1018.81	60
12 30 00	27.25	24.67	27.52	9.13	101.2	113.1	75.9	1018.99	58
13 00 00	27.36	24.59	27.51	8.99	102.9	115.8	74.2	1019.03	60
13 30 00	27.36	24.61	27.53	8.62	99.7	119.0	74.2	1019.15	60
14 00 00	27.39	24.67	27.53	8.74	91.9	124.9	74.5	1019.05	30
** ** **	- TIME GAP -								
16 00 00	27.56	25.34	30.40	9.57	81.0	175.3	76.4	1017.54	4
16 30 00	27.63	25.19	30.40	10.28	81.7	177.8	75.3	1017.57	2
17 00 00	27.72	25.16	29.85	9.55	95.7	134.1	73.6	1017.70	15
17 30 00	27.84	25.12	30.20	8.96	99.5	125.0	72.3	1017.77	18
18 00 00	27.61	25.16	29.64	9.31	82.6	139.0	78.9	1017.32	16
18 30 00	27.68	25.39	30.52	9.50	76.0	134.6	76.3	1017.23	42
19 00 00	28.26	25.64	28.59	10.52	81.4	75.8	78.5	1017.04	60
19 30 00	28.62	25.77	30.00	9.39	82.1	138.7	76.7	1016.82	60
20 00 00	27.93	25.35	27.74	9.66	79.7	122.9	77.4	1016.72	59
20 30 00	27.40	24.87	27.71	10.05	77.2	126.8	77.2	1016.63	60
21 00 00	27.42	24.78	27.54	10.20	81.1	152.0	76.1	1016.78	60
21 30 00	27.41	24.77	27.31	9.38	81.5	152.8	75.8	1016.94	58
22 00 00	27.19	24.87	27.09	9.10	82.1	73.5	78.2	1017.41	60
22 30 00	26.92	24.84	26.84	9.12	82.6	96.6	80.5	1017.83	60
23 00 00	26.99	24.95	26.93	8.92	79.8	125.2	81.1	1017.92	59
23 30 00	27.08	25.06	27.04	8.18	83.3	84.4	81.6	1018.12	60
00 00 00	27.28	25.02	27.25	9.57	79.9	112.5	79.2	1018.11	60
00 30 00	27.20	25.07	27.21	10.34	75.5	138.6	80.0	1018.02	1

Figure 1-9. Example of 35-mm microfilm listing of boom 30-min averages.

(3) The 10- and 30-min averages are arithmetic means; no attempt was made to eliminate occasional discrepancies in the data. The time assigned to these averages is the time at the end of the average period.

(4) Time breaks - periods for which the time-code generator signal could not be deciphered (see discussion of Time Edit/Time Copy procedure in sec. 1.1.2) - of less than 10 min or 30 min will not appear on the microfilm tabulations of the Boom Surface Meteorological Data. The 30-sec samples during a time break were not included in the averages.

(5) Boom wind speeds were not corrected for ship motion (see sec. 1.4.2).

(6) All processed Boom Surface Meteorological Data have not been corrected for instrumental bias.

(7) The wet-bulb sensor was apparently affected by heating or drying of the water reservoir.

(8) Periods during which the sea-surface temperature probe was removed from the sea while the ship was underway are not indicated in the output.

(9) The wet-bulb and dry-bulb temperature circuits were adjusted during the day (usually around 1400 to 1600 GMT) but calibration data of this type were not used for correction during "A_0" processing.

Table 1-9. Ship's barometer and Rosemount heights above sea surface

Ship	Height above sea surface			Barometer
Oceanographer	27 ft	=	8.230 m	Rosemount and aneroid
Rainier	30 ft	=	9.144 m	Rosemount and aneroid
Mt. Mitchell	30 ft	=	9.144 m	Rosemount and aneroid
Discoverer	22 ft	=	6.706 m	Aneroid only
	12 ft	=	3.658 m	NCAR barometer only
Rockaway	23 ft	=	7.010 m	Rosemount and aneroid

(10) All net radiation values must be adjusted by a factor of (200/120). This is the first estimate for the correction. Additional information about the nature of this correction can be obtained from Dr. P. Kuhn, Environmental Research Laboratories, NOAA, Boulder, Colorado 80302.

(11) Rockaway wind directions during Observation Periods I and II should be disregarded. These data are in error.

(12) From Mt. Mitchell 30-sec gyro values that exceed 360°, 360° should be subtracted.

(13) Rockaway wind speeds are in knots, not meters per second.

1.2.2.4 "A_0" Boom Surface Meteorological Data Archive Magnetic Tape Format

Data for one ship for one BOMEX Phase (or Period) are on one magnetic tape. The first file on each tape contains card image records describing the data. In this file, the first record is "BOMEX A-ZERO SURFACE DATA" (25 characters). The second record gives ship name, ship number, BOMEX phase, and inclusive dates of observations. Example: "OCEANOGRAPHER, SHIP NUMBER Ø, PHASE III, JUNE 20 - JULY 3, JULIAN DAYS 171-184." The ship number is character 27; the Julian days are in characters 69-71 and 73-75. Additional records give details on the format of the data files.

The second and successive files contain data for one day each. One end-of-file mark separates adjacent files. There is a triple end-of-file mark after the last data file on each tape.

There are 12 data words per scan and the format is: F10.0, 4F10.2, 3F10.0, F10.1, 3F10.3. Each record, except the last, contains 33 scans (3,960 characters). The last record will generally have less than 33 scans. Data elements are:

Scan Word	Data	Format
1	time, day, hours, minutes, and seconds	F10.0
2	dry-bulb temperature, degrees C	F10.2
3	wet-bulb temperature, degrees C	F10.2
4	sea-surface temperature, degrees C	F10.2
5	wind speed, meters per second	F10.2
6	wind direction, degrees true	F10.0
7	ship's heading (gyro), degrees true	F10.0
8	relative humidity, percent (from boom sensor)	F10.0
9	surface pressure, millibars	F10.1
10	incident radiation, langleys/minute	F10.3
11	reflected radiation, langleys/minute	F10.3
12	net radiation, langleys/minute	F10.3

-9999. is used as a no-data indicator.

1.3.0 BOMEX MARINE METEOROLOGICAL OBSERVATIONS AND SURFACE-PRESSURE - MARINE MICROBAROGRAM DATA

In additon to the surface observations recorded automatically by the boom instrumentation on the five fixed ships (see preceding section), conventional manual observations were made from the ships' decks and/or by permanently installed shipboard instruments. These data should be used with the same caution one would apply to routine marine observations, because data were obtained by crewmen or technicians with varying degrees of skill and dedication, the exposure of the sensors was usually not optimum, and the observations were influenced by the usual perturbations caused by the mass of the ship, while the boom arrangement discussed in the preceding section was designed to minimize such deficiencies. These surface meteorological observations, which were not recorded automatically on SCARD, were entered on the Surface Observations Form shown in figure 1-10. The parameters involved and the method of entering the data on the form are discussed in the section that follows; section 1.3.2 deals with the procedures for processing the data and with the archive magnetic tape format. For the inventory of the data products available in the archive and ordering instructions, see section 4.0.0, Data Ordering Instrutions and Costs.

1.3.1 Observation Procedures and Parameters Measured.

Each parameter is discussed here in the order in which it was entered by the observer on the Surface Observations Form (see fig. 1-10), an 80-column punched-card format.

> NOTE: As the sample form in figure 1-10 shows, the columns were misnumbered, i.e., column 46 is not indicated and two columns are numbered 58. In recording, this deficiency was taken into account, and the parameters were recorded in the order in which they are described below.

Card Code - Column 1. Code 1 was used on each form to identify it as being a surface meteorological observation.

Card Code - Column 2. The following codes identify the ship from which observations were made: 0, *Oceanographer*; 1, *Rainier*; 2, *Mt. Mitchell*; 3, *Discoverer*; 4, *Rockaway*.

Date and Time - Columns 3 through 9. Julian day and time of observation in GMT to the nearest minute, not exceeding 5 min before or after the beginning or end of the surface observation sequence.

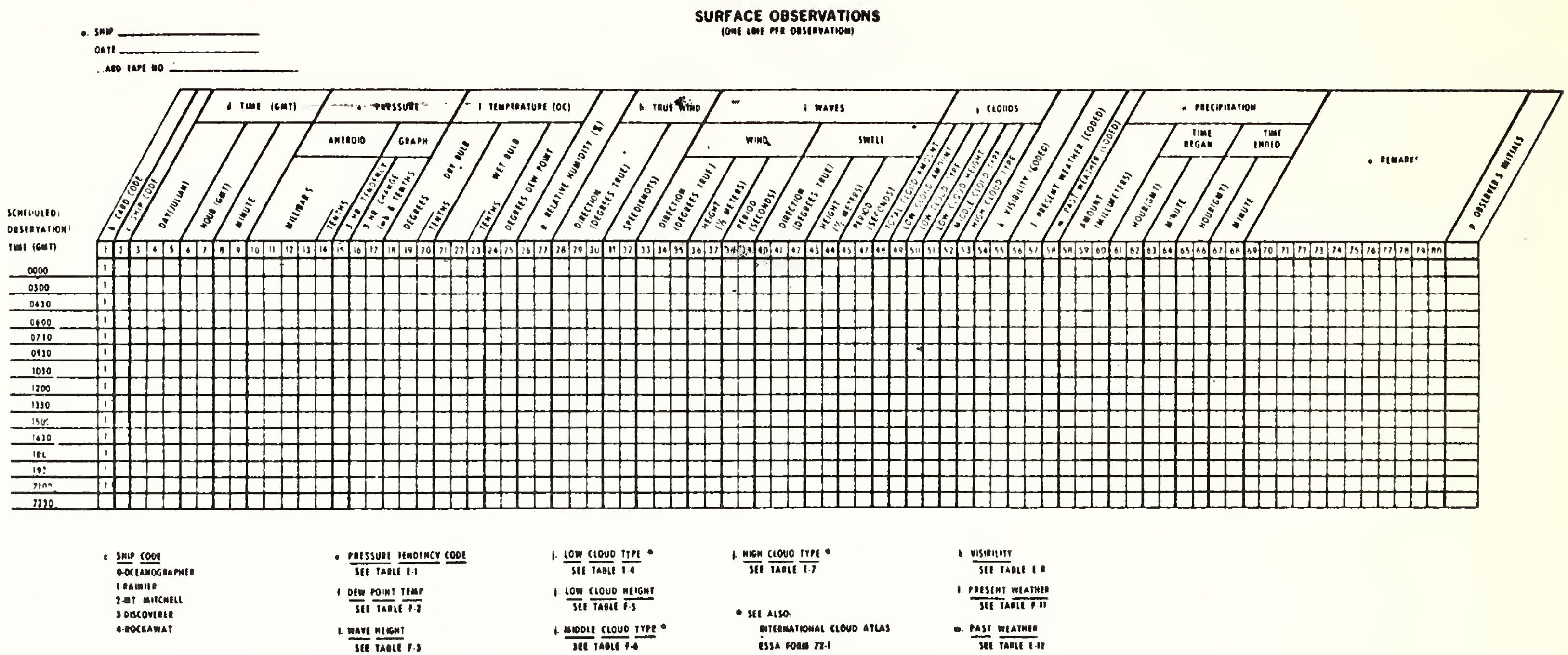


Figure 1-10. Surface Observations Form.

Sea-Level Atmospheric Pressure - Columns 10 through 17. Pressure was determined from a precision aneroid barometer and read to the nearest 0.1 mb, estimating for values between scale graduations and applying correction recorded on the face of the instrument, and then entered in columns 10 through 14 to the nearest 0.1 mb. Values less than 1,000.0 mb are preceded by a zero, i.e., 998.2 mb is recorded as 09982.

Pressure tendency was determined from a marine microbarograph by finding the net amount of pressure change over a 3-hour period through determination to the nearest 0.1 mb of the difference in pressure between the beginning and the end of the period. The appropriate code was entered in column 15 on the form in accordance with the codes shown in table 1-10. The amount of 3-hour change in pressure was entered in millibars and tenths in columns 16 and 17.

Temperature - Columns 18 through 25. Dry-bulb temperature as measured by an ordinary thermometer exposed to the free air on the windward side of the ship, under conditions that eliminated as completely as possible the effects of extraneous sources of heat, was entered in columns 18, 19, and 20 in degrees and tenths. Wet-bulb temperature,representing the lowest temperature secured by evaporating water from a muslin-covered bulb of a thermometer at a specified rate of ventilation, was entered in columns 21, 22, and 23 in degrees and tenths. When the dry-bulb and wet-bulb temperatures were known, the dew point was determined from table 1-11. By subtracting the wet-bulb temperature from the dry bulb, the wet-bulb depression was obtained. The nearest depression across the top of the table and the nearest wet-bulb temperature along the side were then located, and the value at the intersection of the two was entered in columns 24 and 25 in whole °C.

Relative Humidity - Columns 26 and 27. Relative humidity to the nearest whole percent as determined from table 1-12, which was used in the same manner as table 1-11.

True Wind - Columns 28 through 32. Aboard the fixed ships, the true wind could not be read directly from the anemometer indicator. Since "north" on the indicator represents the ship's bow or heading, a reading of 320° would indicate an apparent wind of 040° off the port bow. The apparent wind relative to the bow of the ship was converted to a true compass bearing by adding the apparent wind direction to the ship's heading if the wind was off the starboard bow and by subtracting the apparent wind direction if the wind was off the port bow. Wind speed was read directly from the anemometer indicator and entered in knots.

Aboard the roving ships, the computation of true wind direction and speed was somewhat more complicated and was done by use of a shipboard wind plotter.

Table 1-10. Barometer change characteristics in the last 3 hours

DESCRIPTION OF CHARACTERISTIC: PRIMARY UNQUALIFIED REQUIREMENT	DESCRIPTION OF CHARACTERISTIC: ADDITIONAL REQUIREMENTS	Code Figure
HIGHER Atmospheric pressure now higher than 3 hours ago.	Increasing, then decreasing.	0
	Increasing, then steady; or increasing, then increasing more slowly.	1
	Increasing: Steadily Increasing: Unsteadily	2
	Decreasing or steady, then increasing; or increasing, then increasing more rapidly.	3
THE SAME Atmospheric pressure now same as 3 hours ago.	Increasing, then decreasing.	0
	Steady or unsteady	4
	Decreasing, then increasing.	5
LOWER Atmospheric pressure now lower than 3 hours ago.	Decreasing, then increasing.	5
	Decreasing, then steady; or decreasing, then decreasing more slowly.	6
	Decreasing: Steadily Decreasing: Unsteadily	7
	Steady or increasing, then decreasing; or decreasing, then decreasing more rapidly.	8

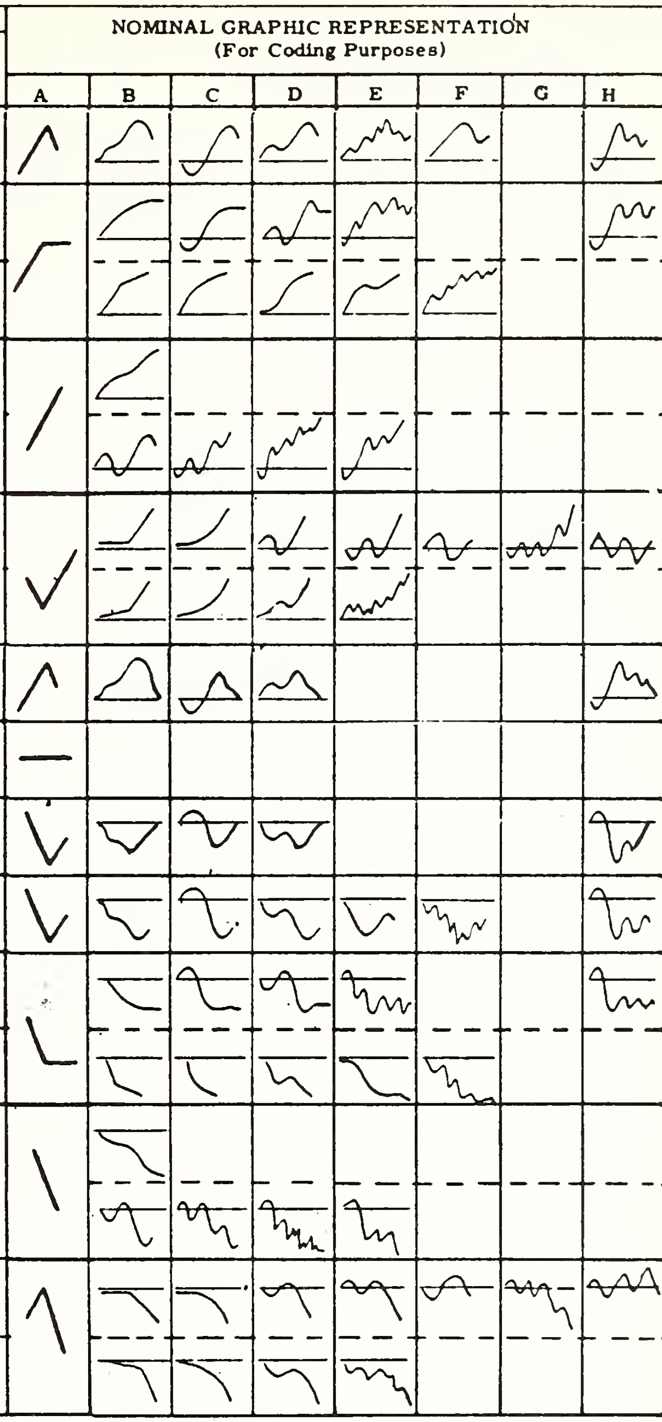


Table 1-11. Dew-point temperature

Wet-bulb temp. °C	Wet-bulb depression, °C																		
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0
10	10	10	09	09	08	08	07	07	06	06	05	05	04	04	03	02	02	01	00
11	11	11	10	10	09	09	09	08	08	07	07	06	06	05	04	04	03	03	02
12	12	12	11	11	11	10	10	09	09	08	08	07	07	06	06	05	05	04	04
13	13	13	12	12	12	11	11	10	10	10	09	09	08	08	07	07	06	06	05
14	14	14	13	13	13	12	12	12	11	11	10	10	10	09	09	08	08	07	07
15	15	15	14	14	14	13	13	13	12	12	12	11	11	10	10	10	09	09	08
16	16	16	15	15	15	15	14	14	14	13	13	13	12	12	11	11	11	10	10
17	17	17	16	16	16	16	15	15	15	14	14	14	13	13	13	12	12	12	11
18	18	18	18	17	17	17	16	16	16	16	15	15	15	14	14	14	13	13	13
19	19	19	19	18	18	18	17	17	17	17	16	16	16	15	15	15	15	14	14
20	20	20	20	19	19	19	19	18	18	18	18	17	17	17	16	16	16	16	15
21	21	21	21	20	20	20	20	19	19	19	19	18	18	18	18	17	17	17	17
22	22	22	22	21	21	21	21	21	20	20	20	20	19	19	19	19	18	18	18
23	23	23	23	22	22	22	22	22	21	21	21	21	20	20	20	20	20	19	19
24	24	24	24	23	23	23	23	23	22	22	22	22	22	21	21	21	21	20	20
25	25	25	25	24	24	24	24	24	24	23	23	23	23	23	22	22	22	22	21
26	26	26	26	26	25	25	25	25	25	24	24	24	24	24	23	23	23	23	23
27	27	27	27	27	26	26	26	26	26	26	25	25	25	25	25	24	24	24	24
28	28	28	28	28	27	27	27	27	27	27	26	26	26	26	26	26	25	25	25
29	29	29	29	29	28	28	28	28	28	28	28	27	27	27	27	27	27	26	26
30	30	30	30	30	29	29	29	29	29	29	29	29	28	28	28	28	28	27	27
31	31	31	31	31	31	30	30	30	30	30	30	30	29	29	29	29	29	29	28
32	32	32	32	32	32	31	31	31	31	31	31	31	30	30	30	30	30	30	30
33	33	33	33	33	33	32	32	32	32	32	32	32	32	31	31	31	31	31	31
34	34	34	34	34	34	33	33	33	33	33	33	33	33	32	32	32	32	32	32
35	35	35	35	35	35	34	34	34	34	34	34	34	34	34	33	33	33	33	33

Table 1-12. Relative humidity

Dry-bulb temp. C	Wet-bulb depression, °C																	
	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6
10	98	95	93	90	88	86	83	81	79	77	74	72	70	68	66	63	61	59
11	98	95	93	91	89	86	84	82	80	78	75	73	71	69	67	65	62	60
12	98	96	93	91	89	87	85	82	80	78	76	74	72	70	68	66	64	62
13	98	96	93	91	89	87	85	83	81	79	77	75	73	71	69	67	65	63
14	98	96	94	92	90	88	86	84	82	79	78	76	74	72	70	68	66	64
15	98	96	94	92	90	88	86	84	82	80	78	76	74	73	71	69	67	65

Dry-bulb temp. C	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5
16	95	90	85	81	76	71	67	63	58	54	50	46	42	38	34	30	26	23	19
17	95	90	86	81	76	72	68	64	60	55	51	47	43	40	36	32	28	25	21
18	95	91	86	82	77	73	69	65	61	57	53	49	45	41	38	34	30	27	23
19	95	91	87	82	78	74	70	65	62	58	54	50	46	43	39	36	32	29	26
20	96	91	87	83	78	74	70	66	63	59	55	51	48	44	41	37	34	31	28
21	96	91	87	83	79	75	71	67	64	60	56	53	49	46	42	39	36	32	29
22	96	92	87	83	80	76	72	68	64	61	57	54	50	47	44	40	37	34	31
23	96	92	88	84	80	76	72	69	65	62	58	55	52	48	45	42	39	36	33
24	96	92	88	84	80	77	73	69	66	62	59	56	53	49	46	43	40	37	34
25	96	92	88	84	81	77	74	70	67	63	60	57	54	50	47	44	41	39	36
26	96	92	88	85	81	78	74	71	67	64	61	58	54	51	49	46	43	40	37
27	96	92	89	85	82	78	75	71	68	65	62	58	56	52	50	47	44	41	38
28	96	93	89	85	82	78	75	72	69	65	62	59	56	53	51	48	45	42	40
29	96	93	89	86	82	79	76	72	69	66	63	60	57	54	52	49	46	43	41
30	96	93	89	86	83	79	76	73	70	67	64	61	58	55	52	50	47	44	42
31	96	93	90	86	83	80	77	73	70	67	64	61	59	56	53	51	48	45	43
32	96	93	90	86	83	80	77	74	71	68	65	62	60	57	54	51	49	46	44
33	97	93	90	87	83	80	77	74	71	68	66	63	60	57	55	52	50	47	45
34	97	93	90	87	84	81	78	75	72	69	66	63	61	58	56	53	51	48	46
35	97	94	90	87	84	81	78	75	72	69	67	64	61	59	56	54	51	49	47
36	97	94	90	87	84	81	78	75	73	70	67	64	62	59	57	54	52	50	48
37	97	94	91	87	84	82	79	76	73	70	68	65	63	60	58	55	53	51	48
38	97	94	91	88	84	82	79	76	74	71	68	66	63	61	58	56	54	51	49
39	97	94	91	88	85	82	79	77	74	71	69	66	64	61	59	57	54	52	50
40	97	94	91	88	85	82	80	77	74	72	69	67	64	62	59	57	54	53	51

Waves - Columns 33 through 46. The wave data, as entered on the Surface Observations Form consist of the direction, height, and period of wind waves and swells. Wind waves, or "sea," are those raised by the local wind blowing at the time of observation; waves due either to winds blowing at a distance or to winds that have ceased to blow are known as swells.

The direction from which the waves were coming was determined visually or, more accurately, by sighting from a compass along the wave crests and adding or subtracting 90°. Ship's heading was also used as a guide. The averages of several observations were recorded to the nearest degree in columns 33, 34, 35 for wind waves and in columns 40, 41, 42 for swells. When no wind waves were present, three zeros were entered. If the waves were from directly north, 360 was used, and if the sea was confused and direction could not be determined, 9's were used.

Wave height as recorded on the form is an average of the estimated heights of the larger well-formed waves. Estimates were made by an observer from the best available point on the ship that permitted the height of the waves to be compared with the height of the ship. Heights in feet were converted to half-meter codes in accordance with table 1-13 and entered in columns 26, 27, and 43, 44, respectively.

Wave period, the interval in seconds between passage of two successive wave crests of well-formed waves past a fixed point, was determined through observation of at least 15 well-formed waves, by (a) selecting a distinctive patch of foam or a small floating object at some distance from the ship, (b) noting the elapsed time to the nearest second between the moments when the object was on the crest of the first and the last wave in the group and noting also the number of crests that passed under the object during the interval, and (c) adding the elapsed times of the various groups together and dividing the total by the number of waves to obtain the average period. The wave period thus obtained was entered in columns 38, 39, and 45, 46 to the nearest second. A calm sea or the absence of either wind or swell is indicated by 00; 99 was used for confused sea.

Clouds - Columns 47 through 52. Total cloud amount, or "sky cover," was estimated in terms of eighths of sky covered by clouds. A few clouds or fragments of clouds were entered as 1 in column 47; if the sky was completely overcast, the amount entered is 8; 7 indicates a few patches of blue sky visible; when blue sky or stars were seen through fog or analogous phenomena, total cloud amount is reported as 0; and when clouds were observed through fog or similar phenomena, their amount is reported as though these phenomena had not been present; 9 indicates that the sky was obscured by fog, rain, or other phenomena, not clouds.

Low cloud amount, recorded in eighths of sky in column 48 was estimated in the same way as total cloud amount.

Low cloud type is indicated in column 49 by the appropriate code chosen from table 1-14. When several types were present in equal amounts, the code entered is that for the type whose base is at the greatest height above the sea, except (a) when types coded 1 and 2 only were present, code 2 was entered,

Table 1-13. Wave or swell heights in half-meters

Half-meters code figure	Feet	Half-meters code figure	Feet	Half-meters code figure	Feet	Half-meters code figure	Feet
01	2	21	34	41	67	61	100
02	3	22	36	42	69	62	102
03	5	23	38	43	71	63	103
04	7	24	39	44	72	64	105
05	8	25	41	45	74	65	107
06	10	26	43	46	76	66	108
07	12	27	44	47	77	67	110
08	13	28	46	48	79	68	112
09	15	29	48	49	80	69	113
10	16	30	49	50	82	70	115
11	18	31	51	51	84	71	117
12	20	32	52	52	85	72	118
13	21	33	54	53	87	73	120
14	23	34	56	54	89	74	121
15	25	35	57	55	90	75	123
16	26	36	59	56	92	76	125
17	28	37	61	57	94	77	126
18	30	38	62	58	95	78	128
19	31	39	64	59	97	79	130
20	33	40	66	60	98	80	131

regardless of amount, and (b) when types coded 3 or 9 were present, 3 or 9 was chosen, as appropriate, regardless of the amount of low cloud.

Height of the bases of the low clouds was determined relatively closely by taking the elapsed time between release and disappearance of the rawinsonde balloon times the ascent rate. The height thus obtained is indicated in column 50 by the appropriate code taken from table 1-15.

Type of middle cloud is indicated in column 51 by the appropriate code from table 1-16, except (a) when altocumulus were present in a chaotic sky, regardless of amount, code 9 was used; (b) when the sky was not chaotic but tufted or turreted altocumulus were present, code 8 was used; (c) clouds observed when the sky was visible through fog or analogous phenomena were recorded as though these phenomena had not been present; and (d) when condensation trails caused by high-flying aircraft persisted and/or cloud masses that had obviously developed from such trails (but not rapidly dissipating trails) were observed, they were reported as middle clouds when they resembled such clouds.

Type of high cloud is indicated in column 52 by the appropriate code taken from table 1-17 for the predominant type present. When several types were present in equal amounts, the code for the type whose base was at the

Table 1-14. Code table for clouds of types Stratocumulus, Stratus, Cumulus, and Cumulonimbus

Code figures	Technical language specifications	Plain language specifications
0	No C_L clouds.	No Cumulus, Cumulonimbus, Stratocumulus or Stratus.
1	Cumulus humilis, or Cumulus fractus other than of bad weather, or both.	Cumulus with little vertical extent and seemingly flattened, or ragged Cumulus other than of bad weather, or both.
2	Cumulus mediocris or congestus, with or without Cumulus of species fractus or humilis, or Stratocumulus; all having their bases at the same level.	Cumulus of moderate or strong vertical extent generally with protuberances in the form of domes or towers, either accompanied or not by other Cumulus or by Stratocumulus; all having their bases at the same level.
3	Cumulonimbus calvus, with or without Cumulus, Stratocumulus or Stratus.	Cumulonimbus the summits of which, at least partially, lack sharp outlines, but are neither clearly fibrous (cirriform), nor in the form of an anvil; Cumulus, Stratocumulus or Stratus may be present.
4	Stratocumulus cumulogenitus.	Stratocumulus formed by the spreading out of Cumulus; Cumulus may also be present.
5	Stratocumulus other than Stratocumulus cumulogenitus.	Stratocumulus not resulting from the spreading out of Cumulus.
6	Stratus nebulosis or Stratus fractus other than of bad weather, or both.	Stratus in a more or less continuous sheet or layer, or in ragged shreds or both, but no Stratus fractus of bad weather.
7	Stratus fractus or Cumulus fractus of bad weather or both (pannus) usually below Altostratus or Nimbostratus.	Stratus fractus of bad weather or Cumulus fractus of bad weather or both (pannus) usually below Altostratus or Nimbostratus.
8	Cumulus and Stratocumulus, other than Stratocumulus cumulogenitus, with bases at different levels.	Cumulus and Stratocumulus, other than those formed from the spreading out of Cumulus; the base of Cumulus is at a different level than that of the Stratocumulus.

Table 1-14. Code table for clouds of types Stratocumulus, Stratus, Cumulus, and Cumulonimbus (continued)

Code figures	Technical language specifications	Plain language specifications
8	Cumulus and Stratocumulus, other than Stratocumulus cumulogenitus, with bases at different levels.	Cumulus and Stratocumulus, other than those formed from the spreading out of Cumulus; the base of Cumulus is at a different level than that of the Stratocumulus.
9	Cumulonimbus capillatus (often with an anvil), with or without Cumulonimbus calvus, Cumulus, Stratocumulus, Stratus or pannus.	Cumulonimbus, the upper part of which is clearly fibrous (cirriform) often in the form of an anvil; either accompanied or not by Cumulonimbus without anvil or fibrous upper part, by Cumulus, Stratocumulus, Stratus, or pannus.
	Clouds C_L not visible owing to darkness, fog, blowing dust or sand, or other similar phenomena.	No Cumulus, Cumulonimbus, Stratocumulus or Stratus visible owing to darkness, fog, blowing dust or sand, or other similar phenomena.

Note: "Bad Weather" denotes the conditions which generally exist during precipitation and a short time before and after.

Table 1-15. Code table for low cloud height; height of base of lowest cloud (C_L or C_M) above sea

Code figure	Height in feet	Height in meters
0	0 - 149	0 - 49
1	150 - 299	50 - 99
2	300 - 599	100 - 199
3	600 - 999	200 - 299
4	1,000 - 1,999	300 - 599
5	2,000 - 3,499	600 - 999
6	3,500 - 4,999	1,000 - 1,499
7	5,000 - 6,499	1,500 - 1,999
8	6,500 - 7,999	2,000 - 2,500
9	8,000 or higher or no clouds	2,500 or higher or no clouds
	Height cannot be reported owing to darkness or other reason	

Table 1-16. Code table for clouds of types Altocumulus, Altostratus, and Nimbostratus

Code figures	Technical language specifications	Plain language specifications
0	No C_M clouds.	No Altocumulus, Altostratus or Nimbostratus.
1	Altostratus translucidus.	Altostratus, the greater part of which is semitransparent; through this part the sun or moon may be weakly visible as through ground glass.
2	Altostratus opacus or Nimbostratus.	Altostratus, the greater part of which is sufficiently dense to hide the sun (or moon), or Nimbostratus.
3	Altocumuls translucidus at a single level.	Altocumulus, the greater part of which is semitransparent; the various elements of the cloud change only slowly and are all at a single level.
4	Patches of Altocumulus translucidus (often lenticular), continuously changing and occurring at one or more levels.	Patches (often in the form of almonds or fishes) of Altocumulus, the greater part of which is semitransparent; the clouds occur at one or more levels and the elements are continually changing in appearance.
5	Altocumulus translucidus in bands, or one or more layers of Altocumulus translucidus or opacus progressively invading the sky; these Altocumulus clouds generally thicken as a whole.	Semitransparent Altocumulus in bands or Altocumulus in one or more fairly continuous layers (semitransparent or opaque) progressively invading the sky; these Altocumulus clouds generally thicken as a whole.

Table 1-16. Code table for clouds of types Altocumulus Altostratus, and Nimbostratus (continued)

Code figures	Technical language specifications	Plain language specifications
6	Altocumulus cumulogenitus (or cumulŏnimbogenitus).	Altocumulus resulting from the spreading out of Cumulus (or Cumulonimbus).
7	Altocumulus translucidus in two or more layers, or Altocumulus opacus in a single layer, not progressively invading the sky, or Altocumulus with Altostratus or Nimbostratus.	Altocumulus in two or more layers usually opaque in places and not progressively invading the sky; or opaque layer of Altocumulus not progressively invading the sky; or Altocumulus together with Altostratus or Nimbostratus.
8	Altocumulus castellanus or floccus.	Altocumulus with sproutings in the form of small towers or battlements, or Altocumulus having the appearance of cumuliform tufts.
9	Altocumulus of a chaotic sky, generally at several levels.	Altocumulus of a chaotic sky, generally at several levels.
	Clouds C_M not visible owing to darkness, fog, blowing dust or sand, or other phenomena, or because of a continuous layer of lower clouds.	No Altocumulus, Altostratus or or Nimbostratus visible owing to darkness, fog, blowing dust or sand, or other similar phenomena, or more often because of the presence of a continuous layer of lower clouds.

Table 1-17. Code table for clouds of types Cirrus, Cirrostratus, and Cirrocumulus

Code figures	Technical language specifications	Plain language specifications
0	No C_H clouds.	No Cirrus, Cirrostratus, or Cirrocumulus.
1	Cirrus fibratus, sometimes uncinus, not progressively invading the sky.	Cirrus in the form of filiments, strands or hooks, not progressively invading the sky.
2	Cirrus spissatus, in patches or entangled sheaves, which usually do not increase and sometimes seem to be the remains of the upper part of a Cumulonimbus; or Cirrus castellanus or floccus.	Dense Cirrus in patches or entangled sheaves which usually do not increase and sometimes seem to be the remains of the upper parts of Cumulonimbus; or Cirrus with sproutings in the form of small turrets or battlements or Cirrus having the appearance of cumuliform tufts.
3	Cirrus spissatus cumulonimbogenitus.	Dense Cirrus often in the form of an anvil, being the remains of the upper parts of Cumulonimbus.
4	Cirrus uncinus, or fibratus, or both, progressively invading the sky; they generally thicken as a whole.	Cirrus in the form of hooks or filaments or both, progressively invading the sky; they generally become denser as a whole.
5	Cirrus, often in bands, and and Cirrostratus, or Cirrostratus alone, progressively invading the sky; they generally thicken as a whole, but the continuous veil does not reach 45° above the horizon.	Cirrus, often in bands converging towards one point or two opposite points of the horizon and Cirrostratus, or Cirrostratus alone; in either case they are progressively invading the sky, and generally growing denser as a whole, but the continuous veil does not reach 45° above the horizon.

Table 1-17. Code table for clouds of types Cirrus, Cirrostratus, and Cirrocumulus (continued)

Code figures	Technical language specifications	Plain language specifications
6	Cirrus, often in bands, and Cirrostratus, or Cirrostratus alone, progressively invading the sky; they generally thicken as a whole, but the continuous veil extends more than 45° above the horizon, without the sky being totally covered.	Cirrus, often in bands converging towards one point or two opposite points of the horizon, and Cirrostratus, or Cirrostratus alone; in either case they are progressively invading the sky, and generally growing denser as a whole; the continuous veil extends more than 45° above the horizon, without the sky being completely covered.
7	Cirrostratus covering the whole sky.	Veil of Cirrostratus covering the celestial dome.
8.	Cirrostratus not progressively invading the sky, and not entirely covering it.	Cirrostratus not progressively invading the sky, and not completely covering the celestial dome.
9	Cirrocumulus alone, or Cirrocumulus predominant among the cirriform clouds.	Cirrocumulus alone, or Cirrocumulus accompanied by Cirrus or Cirrostratus or both, but Cirrocumulus is predominant.
	Clouds C_H not visible owing to darkness, fog, blowing dust or sand or other similar phenomena, or because of a continuous layer of lower clouds.	No Cirrus, Cirrostratus or Cirrocumulus visible owing to darkness, fog, blowing dust or sand, or other similar phenomena, or more often because of the presence of a continuous layer of lower clouds.

greatest height above the sea was used, except (a) clouds observed when the sky was visible through fog or analogous phenomena were reported as though these phenomena had not been present, and (b) persistent condensation trails caused by high-flying aircraft and/or cloud masses obviously developed from such trails were reported as high clouds when they resembled such clouds.

Visibility - Columns 53 and 54. Visibility, or the greatest distance from an observer that an object of known characteristics can be seen and identified was determined, whenever possible, based upon objects whose distance from the observer was known (the horizon or other ships). Appropriate codes from table 1-18 were entered in columns 53 and 54. When the visibility was not the same in all directions, the highest value common to one-half or more of the horizon circle was used; when the visibility was between two of the distances listed in table 1-18, the code for the lesser distance was used.

Table 1-18. Code table for visibility

Code figures	Visibility range
90	Less than 50 yards (50 meters)
91	50 yards (50 meters)
92	200 yards (200 meters)
93	1/4 nautical mile (500 meters)
94	1/2 nautical mile (1,000 meters)
95	1 nautical mile (2,000 meters)
96	2 nautical miles (4,000 meters)
97	5 nautical miles (10 kilometers)
98	10 nautical miles (20 kilometers)
99	25 nautical miles (50 kilometers) or more

Present Weather - Columns 55 and 56. "Present weather" refers to the state of weather at the time of, or within 1 hour before, the observation. The appropriate codes listed in table 1-19 were entered in columns 55 and 56. When more than one code appeared to be required, the highest was entered.

Past Weather - Column 57. "Past weather" refers to the state of weather since the last scheduled observation (either 1 1/2 hours or 3 hours before observation time). The appropriate codes from table 1-20 were used. When two or more codes appeared to be required, the highest code was used.

Table 1-19. Code table for present weather

00-49 No Precipitation at the Station at the Time of Observation.

00-19: No Precipitation, Fog, Ice Fog, Duststorm, Sandstorm, Drifting or Blowing Snow at the Station (or Ship) at the Time of Observation, Except for 09 and 17, or During the Preceding Hour.

	Code	Description	
	00	Cloud development not observed.	Characteristic change of the state of sky during the past hour.
	01	Clouds generally dissolving or becoming less developed.	
	02	State of sky on the whole unchanged.	
	03	Clouds generally forming or developing.	
Haze, Dust, Sand or Smoke	04	Visibility reduced by smoke, e.g., from veldt or forest fires, industrial smoke, or volcanic ashes.	
	05	Haze.	
	06	Widespread dust in suspension in the air, not raised by wind at or near the station (or ship) at the time of observation.	
	07	Dust or sand raised by wind at or near the station (or ship) at the time of observation, but no well developed dust whirl(s) or sand whirl(s) and no duststorm or sandstorm seen.	
	08	Well developed dust whirl(s) or sand whirl(s) seen at or near the station (or ship) within last hour, but no duststorm or sandstorm.	
	09	Duststorm or sandstorm within sight of station (or ship) or at station (or ship) at time of observation or during the last hour.	
	10	Light fog, visibility 1,000 meters (1,100 yards) or more.	
	11	Patches of ...	Shallow fog or ice fog at the station (or ship) not deeper than about 2 meters (6 1/2 feet) on land or 10 meters (33 feet) at sea [visibility less than 1,000 meters (1,100 yards)].
	12	More or less continuous	
	13	Lightning visible, no thunder heard.	
	14	Precipitation within sight, but not reaching ground or surface of the sea.	
	15	Precipitation within sight, reaching ground or surface of the sea, **but distant** [i.e., estimated to be more than 5 kilometers (3 miles) from station (or ship)].	
	16	Precipitation within sight, reaching ground or surface of the sea, near to but not at the station (or ship).	
	17	Thunderstorm, but no precipitation at the time of observation.	
	18	Squall(s)	within sight during the past hour.
	19	Funnel cloud(s)* (tornado or waterspout)	

Table 1-19. Code table for present weather (continued)

20-29:	Precipitation, Fog or Ice Fog or Thunderstorm at the Station (or Ship) During the Preceding Hour But Not at the Time of Observation.	
20	Drizzle (not freezing) or snow grains	not falling as showers.
21	Rain (not freezing)	not falling as showers.
22	Snow	not falling as showers.
23	Rain and snow or ice pellets	not falling as showers.
24	Freezing drizzle or freezing rain	not falling as showers.
25	Shower(s) of rain	
26	Shower(s) of snow, or of rain and snow.	
27	Shower(s) of hail, or of hail and rain.	
28	Fog or ice fog [visibility less than 1,000 meters (1,100 yards)].	
29	Thunderstorm (with or without precipitation).	
30-39:	Duststorm, Sandstorm or Drifting or Blowing Snow.	
30	Slight or moderate duststorm or sandstorm	has decreased during the preceding hour.
31	Slight or moderate duststorm or sandstorm	no appreciable change during the preceding hour.
32	Slight or moderate duststorm or sandstorm	has begun or increased during the preceding hour.
33	Severe duststorm or sandstorm	has decreased during the preceding hour.
34	Severe duststorm or sandstorm	no appreciable change during the preceding hour.
35	Severe duststorm or sandstorm	has begun or increased during the preceding hour.
36	Slight or moderate drifting snow.	Drifting snow 10 meters (33 feet) or below at sea.
37	Heavy drifting snow.	Drifting snow 10 meters (33 feet) or below at sea.
38	Slight or moderate blowing snow.	Blowing snow above 10 meters (33 feet) at sea.
39	Heavy blowing snow.	Blowing snow above 10 meters (33 feet) at sea.
40-49:	Fog or Ice Fog at the Time of Observation [visibility less than 1,000 meters (1,100 yards)].	
40	Fog or ice fog at a distance at the time of observation, but not at the station (or ship) during the last hour, the fog extending to a level above that of the observer.	
41	Fog or ice fog in patches.	
42	Fog or ice fog, sky discernible	has become thinner during the preceding hour.
43	Fog or ice fog, sky not discernible	has become thinner during the preceding hour.
44	Fog or ice fog, sky discernible	no appreciable change during the preceding hour.
45	Fog or ice fog, sky not discernible	no appreciable change during the preceding hour.
46	Fog or ice fog, sky discernible	has begun or has become thicker during the preceding hour.
47	Fog or ice fog, sky not discernible	has begun or has become thicker during the preceding hour.
48	Fog, depositing rime, sky discernible.	
49	Fog, depositing rime, sky not discernible.	

Table 1-19. Code table for present weather (continued)

50-99	**Precipitation at the Station (or Ship) at the Time of Observation.**	
50-59:	**Drizzle at Time of Observation.**	
50	Drizzle, not freezing, intermittent	slight at time of observation.
51	Drizzle, not freezing, continuous	slight at time of observation.
52	Drizzle, not freezing, intermittent	moderate at time of observation.
53	Drizzle, not freezing, continuous	moderate at time of observation.
54	Drizzle, not freezing, intermittent	heavy (dense) at time of observation.
55	Drizzle, not freezing, continuous	heavy (dense) at time of observation.
56	Drizzle, freezing, slight.	
57	Drizzle, freezing, moderate or heavy (dense).	
58	Drizzle and rain, slight.	
59	Drizzle and rain, moderate or heavy.	
60-69:	**Rain at Time of Observation.**	
60	Rain, not freezing, intermittent	slight at time of observation.
61	Rain, not freezing, continuous	slight at time of observation.
62	Rain, not freezing, intermittent	moderate at time of observation.
63	Rain, not freezing, continuous	moderate at time of observation.
64	Rain, not freezing, intermittent	heavy at time of observation.
65	Rain, not freezing, continuous	heavy at time of observation.
66	Rain, freezing, slight.	
67	Rain, freezing, moderate or heavy.	
68	Rain or drizzle and snow, slight.	
69	Rain or drizzle and snow, moderate or heavy.	
70-79:	**Solid Precipitation Not in Showers at Time of Observation.**	
70	Intermittent fall of snowflakes	slight at time of observation.
71	Continuous fall of snowflakes	slight at time of observation.
72	Intermittent fall of snowflakes	moderate at time of observation.
73	Continuous fall of snowflakes	moderate at time of observation.
74	Intermittent fall of snowflakes	heavy at time of observation.
75	Continuous fall of snowflakes	heavy at time of observation.
76	Ice prisms (with or without fog).	
77	Snow grains (with or without fog).	
78	Isolated starlike snow crystals (with or without fog).	
79	Ice pellets (i.e., frozen raindrops or largely melted and refrozen snowflakes).	
80-99:	**Showery Precipitation, or Precipitation With Current or Recent Thunderstorm.**	
80	Rain shower(s), slight.	
81	Rain shower(s), moderate or heavy.	
82	Rain shower(s), violent.	
83	Shower(s) of rain and snow, mixed, slight.	
84	Shower(s) of rain and snow mixed, moderate or heavy.	
85	Snow shower(s), slight.	
86	Snow shower(s), moderate or heavy.	

Table 1-19. Code table for present weather (continued)

87	Shower(s) of snow pellets or ice pellets* with or without rain or rain and snow mixed	slight.
88	Shower(s) of snow pellets or ice pellets* with or without rain or rain and snow mixed	moderate or heavy.
89	Shower(s) of hail, with or without rain or rain and snow mixed, not associated with thunder	slight.
90	Shower(s) of hail, with or without rain or rain and snow mixed, not associated with thunder	moderate or heavy.
91	Slight rain at time of observation	thunderstorm during the preceding hour but not at time of observation.
92	Moderate or heavy rain at time of observation	
93	Slight snow or rain and snow mixed or hail* at time of observation	
94	Moderate or heavy snow, or rain and snow mixed or hail* at time of observation	
95	Thunderstorm, slight or moderate, without hail* but with rain and/or snow at time of observation	thunderstorm at time of observation.
96	Thunderstorm, slight or moderate, with hail* at time of observation	
97	Thunderstorm, heavy, without hail* but with rain and/or snow at time of observation	
**98	Thunderstorm combined with duststorm or sandstorm -- at time of observation.	
99	Thunderstorm, heavy, with hail* at time of observation.	

* Hail, ice pellets, i.e., pellets of snow encased in a thin layer of ice, snow pellets.

** In reporting code figure 98, the observer is allowed considerable latitude in the presumption that precipitation is or is not occurring if it is not actually visible.

Precipitation - Columns 58 through 68. The amount of precipitation was recorded by a Weather Bureau shielded precipitation gage #D101 mounted on the boom of each fixed ship and graduated in millimeters. With care taken to allow for ship movement, the amount of precipitation during, or 1 1/2 or 3 hours before, the observation was read to the nearest millimeter and entered in columns 58, 59, and 60. If precipitation fell, but was too small to be measured, 001 was entered. If no precipitation was observed, 000 was used.

The times of beginning and ending of precipitation were recorded in GMT to the nearest minute in columns 61 through 64 and 65 through 68, respectively. If precipitation began or ended more than once during the observation period, the time of the first beginning and last ending was entered, and the appropriate codes for showery or intermittent activity were entered in the present- and past-weather columns.

Table 1-20. Code table for past weather

Code figure	Past weather
0	Clouds covering 1/2 or less of the sky throughout period
1	Clouds covering more than 1/2 of the sky during part of period, and less than 1/2 during part of period
2	Clouds covering more than 1/2 of the sky throughout period
3	Sandstorm, duststorm, or drifting or blowing snow
4	Fog, or ice fog, or thick haze
5	Drizzle
6	Rain
7	Snow, rain and snow mixed, or ice pellets
8	Shower(s)
9	Thunderstorm(s), with or without precipitation

Orientiation of Low Clouds - Columns 69 through 71. When cumulus clouds arranged in bands or several bands separated by clear spaces (streets) were observed, their presence was recorded by entering code 1 in column 69 of the form; 0 was used if they were not present. The orientation of the cloud street axis with respect to true north is indicated in columns 70 and 71 in accordance with table 1-21. (This information was not reliably reported. If columns 69 through 71 are blank, no observations of this type were made.)

Remarks - Columns 72 through 80. These colums were left open for the observer to record any information he considered pertinent to the observation not allowed for in the form, such as wind shifts, gusting wind, waterspouts, hail, second swell group at least 30° different from the one reported, reasons for missing data or unreliability of some data, and whether the observation was transmitted to the Barbados Control Center, indicated by TRANS. The GMT for all such entries in the remarks column is given. The observer's initials appear in the last column of the Surface Observations Form.

Table 1-21. Code table for orientation of cloud band axis with respect to true north

Code figure	Orientation of band axis with respect to true north along a line			
00	From	0°	to	180°
01	"	10°	"	190°
02	"	20°	"	200°
03	"	30°	"	210°
04	"	40°	"	220°
05	"	50°	"	230°
06	"	60°	"	240°
07	"	70°	"	250°
08	"	80°	"	260°
09	"	90°	"	270°
10	"	100°	"	280°
11	"	110°	"	290°
12	"	120°	"	300°
13	"	130°	"	310°
14	"	140°	"	320°
15	"	150°	"	330°
16	"	160°	"	340°
17	"	170°	"	350°

1.3.2 Processing Procedure and Archive Magnetic Tape Format

1.3.2.1 Processing Procedure

The data logged on the Surface Observations Form (fig. 1-10, sec. 1.3.1) were punched on cards and edited for punching errors. No corrections to these data were attempted during the edit for punching errors nor when the punched cards were written onto magnetic tape for the archive. Time-series plots of the thermodynamic parameters by the BOMAP Office have revealed the usual inconsistencies expected in manually recorded observations and some indications (though not conclusively proven) that heating effects of the ship influenced temperature measurements. This suspected influence became evident when the rawinsonde dry-bulb (150-m sample), boom dry-bulb, and surface observation dry-bulb temperatures were compared in a time-series format.

1.3.2.2 BOMEX Marine Meteorological Observations Archive Magnetic Tape Format

The magnetic tape format consists of six separate files, of which the second one constitutes the BOMEX Marine Meteorological Observations. When these data are requested, all six files will be sent, not the marine meteorological observations alone. The six files of information on this tape are separated from each other by end-of-file mark and followed by a double end-of-file. All information is in binary-coded-decimal (BCD) format, even parity, 800 bits per inch. The first file consists of 80-column card images, one card image per record, describing the formats of the data files. The other five files contain data that were either recorded manually or were read manually from strip-chart recordings; the data are BCD card images, 50 cards (4,000 characters) per record.

The third file contains Ship Operations Data (sec. 1.4.0); the fourth file contains hand-tabulated STD Support Data (sec. 1.7.3); the fifth file contains Radiometersonde Data (sec. 1.1.3.2); the sixth file contains Dropsonde Data (sec. 2.2.3).

As noted above, the second file contains the BOMEX Marine Meteorological Observations. The format is as follows:

Character	Element
1	Card code, should always be 1
2	Ship code
	0 - *Oceanographer*
	1 - *Rainier*
	2 - *Mt. Mitchell*
	3 - *Discoverer*
	4 - *Rockaway*
3-5	Modified Julian day (day of year)

6-7	Hour, GMT
8-9	Minute
10-14	Station pressure, millibars and tenths
15	Three-hour pressure tendency (see table 1-10, sec. 1.3.1)
16-17	Three-hour pressure change, millibars and tenths
18-20	Dry-bulb temperature, degrees and tenths Celsius
21-23	Wet-bulb temperature, degrees and tenths Celsius
24-25	Dew-point temperature, degrees Celsius
26-27	Relative humidity, percent
28-30	Wind direction, degrees true
31-32	Wind speed, knots
33-35	Direction from which wind waves come, degrees true
36-37	Wind-wave height, half-meters
38-39	Wind-wave period, seconds
40-42	Direction from which swell comes, degrees true
43-44	Swell height, half-meters
45-46	Swell period, seconds
47	Total cloud amount, eighths
48	Low cloud amount, eighths
49	Low cloud type (see table 1-14, sec. 1.3.1)
50	Low cloud height (see table 1-15, sec. 1.3.1)
51	Middle cloud type (see table 1-16, sec. 1.3.1)
52	High cloud type (see table 1-17, sec. 1.3.1)
53-54	Visibility (see table 1-18, sec. 1.3.1)
55-56	Present weather (see table 1-19, sec. 1.3.1)
57	Past weather (see table 1-20, sec. 1.3.1)
58-60	Precipitation amount, millimeters
61-62	Hour precipitation began, GMT
63-64	Minute precipitation began
65-66	Hour precipitation ended, GMT
67-68	Minute precipitation ended,
69-80	Remarks

1.4.0 FIXED-SHIP OPERATIONS DATA

Ship operations and navigation data were recorded manually on the Ship Operations Form shown in figure 1-11. The method of entering the data is discussed in the section that follows; section 1.4.2 deals with ship operations, section 1.4.3 with data processing, and section 1.4.4 with the archive magnetic tape format. For the inventory of data products available in the temporary archive and instructions for ordering, see section 4.0.0, Data Ordering Instructions and Costs.

1.4.1 Parameters Recorded

On the Ship Operations Form (fig. 1-11), observations were recorded as follows:

Card Code - Column 1. Code 4 was used on each form to identify it as pertaining to ship operations and navigation data.

Ship Code - Column 2. The following codes were used to designate the ship from which observations were made: 0, *Oceanographer*; 1, *Rainier*; 2, *Mt. Mitchell*; 3, *Discoverer*; 4, *Rockaway*.

Date and Time - Columns 3 through 9. Julian day and time of observation in GMT was entered to the nearest minute.

Latitude - Columns 10 through 14. The actual latitude in degrees and minutes for the ship's position at the time of observation was entered in columns 10 through 13. Code 1 for north and code 2 for south were used in column 14.

Longitude - Columns 15 through 20. Actual longitude in degrees and minutes for the ship's position at the time of observation was entered in columns 15 through 19. Code 3 was used for east and code 4 for west in column 20.

Means of Navigation - Column 21. The method used for determining the ship's latitude and longitude at the time of observation was indicated by choosing the appropriate code from the following: 1, Dead reckoning (DR); 2, Astro; 3, Omega; 4, Loran A; 5, Loran C; 6, Satellite; 7, Radar; 8, Visual.

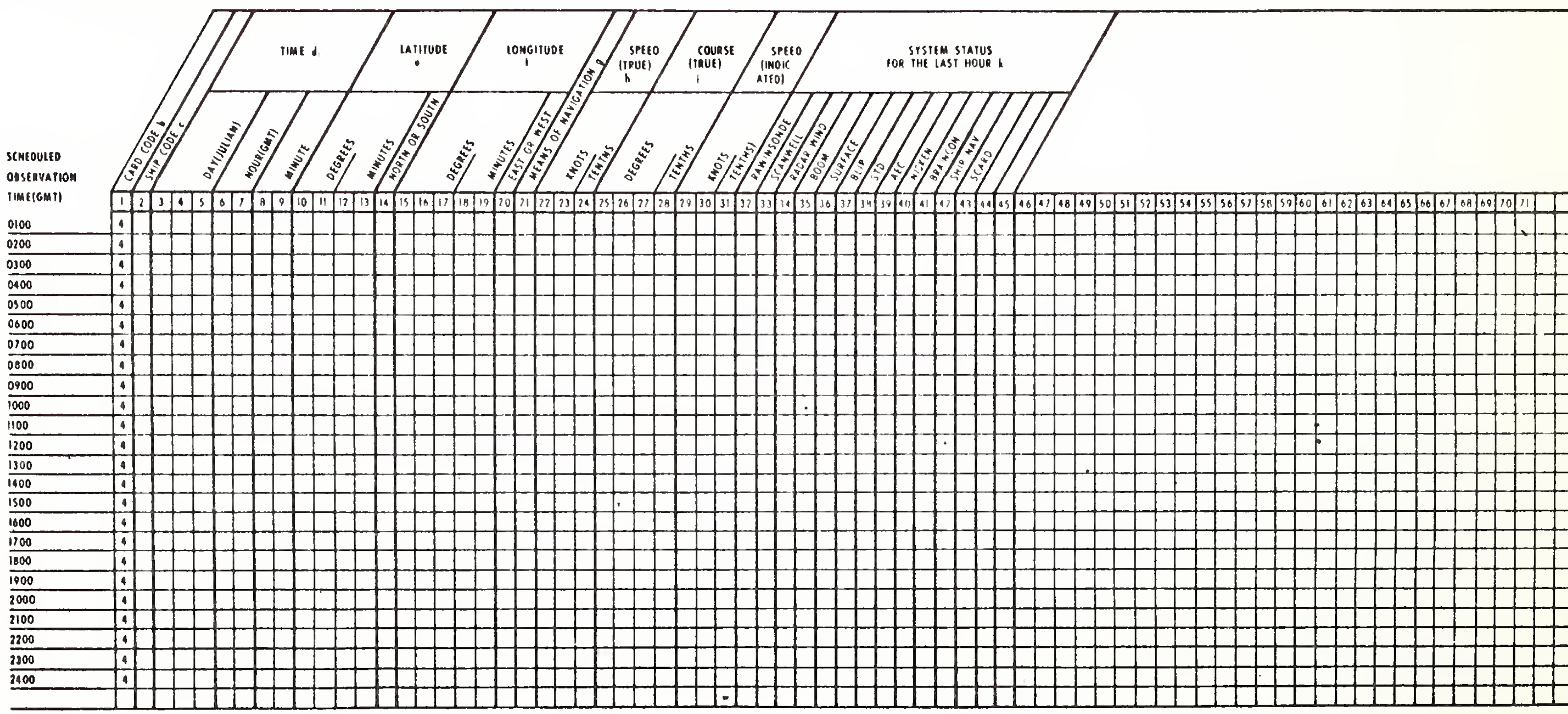
True Speed - Columns 22, 23, and 24. As determined from the navigational plot, the ship's true speed was recorded in knots and tenths. If the speed had changed during the preceding hour, the speed at the time of observation was used.

SHIP OPERATIONS
(ONE LINE PER HOUR)

a. SHIP ____________

DATE ____________

SCARD MAG TAPE NO ____________



b. CARD CODE -4

c. SHIP CODE

0-OCEANOGRAPHER
1-RAINIER
2-MT. MITCHELL
3-DISCOVERER
4-ROCKAWAY

e. 1-NORTH
2-SOUTH

f. 3-EAST
4-WEST

g. MEANS OF NAVIGATION

1. OR
2. ASTRO
3. OMEGA
4. LORAN A
5. LORAN C
6. SATELLITE
7. RADAR
8. VISUAL

k. SYSTEM STATUS CODES

0 - OPERATIONAL
1 - PARTIALLY
2 - NON-OPERATIONAL,REPAIRABLE
3 - NON-OPERATIONAL,NON-REPAIRABLE

Figure 1-11 Ship Operations Form.

True Course - Columns 25 through 28. The ship's heading was recorded to the nearest degree and tenth of a degree. This was done at the actual time of the observation.

Indicated Speed - Columns 29, 30, and 31. The ship's speed as indicated by the pit log or other device at the time of the observation was entered in knots and tenths.

System Status - Columns 32 through 43. These entries indicate the status of the following ship observation systems: rawinsonde; Scanwell WFSS; radar wind; meteorological boom instrumentation; surface observation system; BLIP; STD; AEC air, rain, and water sampler; Niskin water sampler; Braincon current meter; ship navigation system; and SCARD. For each of these, code 0 was entered if the system was operational, code 1 if it was partly operational, code 2 if it was nonoperational but reparable, and code 3 if it was nonoperational and nonreparable.

Columns 44 and 45. Not used.

Ship's Gyro Correction - Columns 46 through 49. The ship's gyro correction was indicated in column 46 by a plus or a minus sign and recorded in columns 47, 48, and 49 in degrees and tenths.

Final two columns of the form. Observer's initials.

1.4.2 Fixed-Ship On-Station and Underway Operations

For a chronological listing of ship operations, refer to table 1-2, section 1.0.0. As mentioned in that section, each fixed ship was equipped with a free-fall, deep-sea mooring system to maintain its position. However, the *Rainier*'s mooring system failed on May 1, the *Mt. Mitchell*'s on May 3, the *Rockaway*'s on May 25, and the *Discoverer*'s and *Oceanographer*'s on June 21. All wind speed and wind direction data acquired after mooring failure -- during "steam and drift" periods -- must be corrected for ship motion. Renavigation studies are underway, but no corrections for ship motion have been applied to wind data acquired from the fixed ships after mooring failure. A user who needs to develop such corrections should check not only the Fixed-Ship Operations Data (latitude, longitude, and speed), but also the ship's gyro heading from the Boom Surface Meteorological Measurements described in section 1.2.0, and the BOMEX Fixed-Ship Event Log described in section 1.5.0.

As expected, the Fixed-Ship Operations Data contain discrepancies attributable to manually logged data and navigation errors normally associated with the conventional navigation systems used. To aid the user in assessing the quality of the navigation data and procedures used aboard the fixed ships, summaries of each ship's operation follow. These summaries were extracted from reports submitted by the commanding officers of the BOMEX fixed ships at the end of the experiment.

1.4.2.1 USC&GSS Oceanographer Ship Operations and Navigation

The *Oceanographer* occupied two BOMEX array positions -- station BRAVO for Observation Periods I through III and station GOLF during Period IV. The ship arrived on station and deployed its mooring system on May 3. On June 21, approximately 24 hours after the ship had moored upon arrival on station, the anchor cable failed and the ship, still made fast to the buoy, started to drift. Divers sent out to disconnect the mooring cable reported that the cable had broken about 7 ft below the Miller swivel. Wind at the time of failure was from the east and tension was 6,000 lbs. It is believed that the failure was gradual from strain of previous moorings.

Navigation can be divided by two distinct methods -- that required for running track line to and from the stations (at the beginning and end of each Observation Period) and that used for "drift and steam" operation after loss of the mooring on June 21 and while the ship was on station GOLF, where no mooring was available.

During the first three Observation Periods, when the ship occupied station BRAVO, Omega navigational control was not only adequate, but was the only control available except celestial. It is estimated that during periods other than sunrise and sunset the accuracy was within 1/2 mi. At sunrise and sunset the fixes would be off about 3 mi. At station GOLF, Omega was completely worthless and the ship relied on satellite fixes, which were accurate within 1/2 mi or less at all times. The main limitations on satellite fixes are having the pass angle of orbit within the prescribed limits and a minimum number of Doppler returns. At least 80 percent of the fixes are usable and the others close enough for general location.

During Periods I and II, the *Oceanographer* was tied to the anchored mooring system, which minimized on-station movement, although there was movement of as much as 4 mi during a day as the wind and current changed. The effect of this movement on recording instruments was considered minimal. After loss of the mooring on station BRAVO, and on station GOLF, the ship had to go into a "steam and drift" mode of operation in order to remain within the prescribed distance from the station. The best procedure was found to be drifting for 1 hour and steaming for 1/2 hour. A fix was taken at the beginning and end of the run period, producing control sufficiently accurate to take out both the drift and steam components of recorded data.

On station GOLF it was somewhat difficult to take fixes at the preferred times, particularly when the schedule required rawinsonde observations to last 110 min every 3 hours. The satellite navigation system was available at varying times and during some of these times the fixes were not accurate due to low or high pass angles. The best solution was to try to hold within 4 mi of the station by taking satellite fixes whenever possible and steaming back to position between rawinsonde observations. Fortunately, winds on station GOLF were of less force, which required far less steaming than found necessary on BRAVO. Even though the fixes could not be taken at the beginning and end of the steaming times it is believed that the increased accuracy of the satellite fixes during drift periods minimized errors introduced by using dead-reckoning positions.

Navigation presented no problem during BOMEX except for the lack of Omega control on GOLF, which was compensated for by the satellite equipment.

1.4.2.2 USC&GSS Mt. Mitchell Ship Operations and Navigation

The Mt. Mitchell occupied two BOMEX array positions during the four Observation Periods -- station DELTA (12°23'N, 58°23'W) during Periods I, II, and III, and station LIMA (10°30'N, 56°30'W) during Period IV. The ship arrived on station DELTA on May 1. The free-fall mooring system was deployed that day but failed on May 3. The ship then began to operate in a mode consisting of steaming at steerageway speeds and of drifting with engines secured. This mode of operation was maintained not only at DELTA but was also used at station LIMA.

On May 1, the U.S. Coast Guard Cutter Laurel established a current station within a few yards of position DELTA, consisting of a "plank-on edge" mooring buoy that was lighted and fitted with a radar reflector. A series of several dozen celestial observations fixed the position of the buoy at 12°21'N and 58°23'W with a high level of confidence. During Periods I, II, and III, with the buoy as a reference, the Mt. Mitchell obtained visual bearings and/or radar bearings and radar ranges to position the ship relative to the buoy. The position of the buoy was checked daily by Omega fixes and when possible by celestial observations.

During BOMEX Period IV, at station LIMA, 10°30'N and 56°30'W, no buoy was planted and the ship had to rely on Omega for hourly positions with celestial verification mornings and evenings. A general plan of drifting 3 to 4 hours and then returning to station was contemplated, but because of the slow drift and the inaccuracy of Omega this drifting period was extended in some cases and a celestial fix was taken before steaming toward the station.

At both stations the ship would bracket the station position either by steaming very slowly "up current" or by securing the engines and drifting "down current," the current being the result of both ocean current and wind effects on the ship. The distance in this "steam and drift" mode of operation was held within 3 n mi when possible.

Omega rates A-D, A-C, and B-D picked on the basis of available Omega tables for the BOMEX area were used and were found to have mediocre intersections. This had the effect of increasing Omega error. The rate B-D (Trinidad - New York) was inaccurate due to ground-wave mixing from Trinidad. This problem was solved by generating on-the-spot sky-wave corrections. These corrections, which are the heart of Omega navigation because they determine position accuracy, were generated by the USC&GSS Rainier during each in-port period between BOMEX Observation Periods for rates A-D and A-C. The Mt. Mitchell generated its own corrections for B-D at station DELTA, but due to the distance between station LIMA and Bridgetown these corrections were found to be below standard. The combination of unreliable sky-wave corrections and weak intersection of the Omega rates increased unadjusted position error from approximately 2 mi (minimum) to 6 mi (maximum) in some cases.

1.4.2.3 USC&GSS Rainier Ship Operations and Navigation

The Rainier was operated in a "drift and steam" mode throughout the four BOMEX Observation Periods. The ship occupied position ALFA (16°50'N, 59°12'W) during Observation Periods I through III and position BRAVO (17°30'N, 54°00'W) during Observation Period IV.

The initial plan for the fixed ships was to use deep-sea anchoring systems to eliminate slow speed running to hold station. After failure of its mooring, the Rainier adopted a slow speed steaming mode running generally NE and SE, quartering the expected wind and currents. The intent to use just enough power to remain stationary in one position did not always prove effective because of unexpected current velocities. This procedure was used for Periods I and II; however, during Period III, the ship would shut down both main engines and lay in the trough of the sea, a procedure that was largely effective. Power was applied to the ship when necessary to change the ship's heading for rawinsonde tracking or STD lowerings, or to return to station ALFA. Before Period IV, a change in the Operations Plan established a "steam and drift" mode for all ships, a procedure that was tried throughout Period IV, when the Rainier was positioned at station BRAVO. Due to the requirement to change ship's heading for rawinsonde tracking, the port main engine was kept on the line throughout most of this period.

Omega receiving systems, Tracor Series 599, were furnished for all fixed ships. The equipment functioned quite well during the entire BOMEX project. Due to insufficient data on sky-wave corrections within the array, serious jumps in position were experienced at sunrise and sunset. During each in-port period, Omega stations A, B, C, and D were monitored and average hourly corrections were provided to the other four ships. However, the corrections did not prove usable over the entire 90,000 mi^2 covered by the BOMEX array. Because of fairly heavy cloud cover, celestial control was impossible to obtain. Some adjustment of Omega positions will be necessary to smooth out spurious values obtained at sunrise and sunset.

1.4.2.4 USC&GSS Discoverer Ship Operations and Navigation

The Discoverer occupied position ECHO during all four BOMEX Observation Periods. The ship was moored from May 6 to June 20. On June 21, the mooring failed, and the ship began a "steam and drift" mode of operation.

The mooring was established in approximately 2,800 fathoms of water. It held the ship in winds to 25 kt during the first two Observation Periods. During these periods, the wind and current were in different directions. Tension in the anchor cable normally ran 2,500 lbs, 3,500-4,000 lbs, and 5,000-7,500 lbs with a wind speed of 15 kt, 20 kt, and 25 kt, respectively. When the tension reached 7,000 lbs, the ship would steam ahead dead slow on one engine to ease the strain down to 4,500 lbs. During this time the ship lay at an angle of from 30° to 90° to the anchor cable. For one period of approximately 20 hours it lay directly north of the buoy with less than 500 lbs of tension, despite an easterly wind of 15 kt, indicating a good current setting to the east.

During Period III, the wind and current were in the same direction, indicated by the fact that the ship headed directly toward the anchor cable and tension built up to 7,500 lbs with wind less than 20 kt. Despite steaming on the wire, the cable parted after approximately 18 hours. It parted about 1,500 to 1,800 fathoms down from the buoy, judging by the depth of the buoy at first launch and before and after failure. The cause of failure is unknown, but is believed to be that the current drag on the cable and the ship's tension on the buoy were in the same direction, as opposed to Periods I and II, when the current and direction of ship's tension were in two different directions.

When the mooring failed, an attempt was made at first to keep the ship directly on station by steaming slowly (20 to 55 turns on one shaft) into the wind. If accurate control had been available, this would probably have been the most desirable procedure, since the wind, current, and ship's steaming would nullify one another, and the ship would be stationary. However, the only control available other than celestial was Omega, which did not furnish control to the necessary accuracy. Jumps of as much as 8 to 10 mi occurred from hour to hour. The Omega readings would plot in two or three different positions within a 20-mi area without definite lane identification, which the Discoverer's Omega did not have. Readings on different frequencies did not resolve the ambiguity of position.

The direction and velocity of current on the station site were not constant, adding to the difficulty of attempting to maintain station or making good courses steered.

After 6 days, the ship abandoned the attempt to remain on station by continuous steaming. A procedure was adopted of drifting for approximately 6 or 7 hours, and then steaming for 1 or 2 hours back to and past the station. By this procedure enough time was allowed during drifting to obtain an approximate drift rate and direction even with erratic fixes. The ship would then proceed back at the maximum speed that would not disrupt the instrumented boom extending from the ship's bow. Steaming times were selected that would interfere least with the observations being made. By this procedure the ship might have drifted as much as 15 mi off station, but relative movements could be approximated by using the Omega readings only. Celestial fixes and lines of position kept track of absolute position but could not be combined with Omega for drift rates.

1.4.2.5 USCGC Rockaway Ship Operations and Navigation

The Rockaway occupied BOMEX array position CHARLIE throughout all four BOMEX Observation Periods and was operated in two modes -- one moored, and the other steaming and drifting to maintain position on station.

The Rockaway's deep-sea mooring system was deployed on May 2, 1969. The launch position of the system was determined by Florida State University's Triton buoy previously moored at position CHARLIE by the USCGC Laurel. Because of a practical requirement for the Rockaway to be outside the radius of the Triton's mooring, the ship's anchor was dropped 300 yards downwind from the Triton. The ship was made fast to the buoy paying out a 350-ft catenary

through the bullnose. The ship was 400 ft from the mooring buoy, since the 350-ft nylon mooring line was attached to a 50-ft pendant at the mooring buoy.

While the ship was moored, its position was always known with a very high degree of confidence. Triton's position was confirmed each day by celestial fix, and once every 30 min the Rockaway confirmed its position with reference to the Triton by a radar range and bearing. By means of a Universal Plotting Sheet (UP-OS), with a scale change so that 1 inch equalled 1 n mi, the ship's position was reported once every hour on the BOMEX Ship Operations Form (fig. 1-11, sec. 1.4.1). The ship rode comfortably -- even though stopped it did not lie in the trough -- during high seas and wind conditions with 8-ft swells and 25-kt winds, which were the worst encountered during Period I. The mooring was used from May 2 to May 14. On May 25, after returning to station CHARLIE from the in-port period between BOMEX Observation Periods I and II, the mooring system was remade, and mooring was tried after the ship had been on station for 35 hours, during which rough seas discouraged small-boat operations necessary for mooring to the buoy. During the first 4 hours after mooring, the ship's drift rate remained constant (tension remaining steady at approximately 1,350 lbs) and the range between the Rockaway and the Triton buoy opened up from 5,400 yards to 10,600 yards. At first the ship's navigator thought that the excessive range between the Triton and the ship was attributable to the fact that the Triton's drift about the scope of its mooring was the result only of ocean currents, while the Rockaway's drift was a result of both ocean currents and wind effects. However, the range continued to open up, and eventually the Triton was lost on radar. A celestial fix 14 hours after the attempt to moor was made indicates the ship was 13 mi off station (as defined relative to the Triton). In the next 24 hours, the ship had drifted to a total of 30 mi off station. The mooring buoy was then sunk and the ship proceeded back to station.

After the mooring failure during Period II, and during the subsequent BOMEX Observation Periods, a continuous plot of the ship's position and movement, whether underway or adrift, was kept. Except as modified by small-boat operations, the daily routine during Periods II, III, and IV was to drift downwind each day from 0830 to 1930 GMT and from 2100 to 0700 GMT. (During Period I small-boat operations occurred every day except one. During Periods II, III, and IV, small-boat operations occurred once every 4 days.) During the remaining two periods of 1 1/2 hours, the ship would be underway, proceeding upwind.

A revised plotting grid provided an accurate chart with a scale of 1 inch to the nautical mile. The Triton was always placed at the center and the coordinates of the chart and the ship's position were plotted relative to the Triton. A geographic plot was maintained on this chart and accurate ship's positions were always available. The true velocity and direction of the ship's movements, whether underway or adrift, were determined by the navigator from these plots on a locally prepared form titled Ship Motion and Position Data. The position data were taken from this form and entered as required on the Ship Operations Form (fig. 1-11, sec. 1.4.1).

The Omega navigation system did not serve a useful purpose. Celestial fixes were usually available, and, when on station, the ship was either moored or keeping station on the anchored Triton buoy.

During Period III, the ship relieved the Oceanographer on station BRAVO for a few days (see table 1-2, sec. 1.0.0). The ship was not moored at BRAVO and the Triton was left at station CHARLIE. Thus, Omega was the only source of position data available for station keeping. The Omega lines for rates A-D, B-C, A-C, and B-D were laid down on a locally prepared chart with a scale of 1 inch equalling 1 n mi. Positions were plotted every 30 min. While these positions, based on an updated lane count, were satisfactory for off-shore trackline navigation, they proved useless for station keeping because of excessive variability in fix quality when compared with the suspected dead-reckoning position.

1.4.3 Fixed-Ship Operations Data Processing

The Fixed-Ship Operations Data were manually logged on the Ship Operations Form (see fig. 1-11, sec. 1.4.1). This form was converted to punched cards, listed, and edited for punching errors. No other corrections have been applied to the data.

1.4.4 Fixed-Ship Operations Data Archive Magnetic Tape Format

The magnetic tape format consists of six separate files, of which the third one constitutes the Ship Operations Data. When these data on magnetic tape are requested, all six files will be sent, not the Ship Operations Data alone. The six files of information on this tape are separated from each other by end-of-file mark and followed by a double end-of-file. All information is in binary coded decimal (BCD) format, even parity, 800 bits per inch. The first file consists of 80-column card images, one card image per record, describing the formats of the data files. The other five files contain data that were either recorded manually or were read manually from strip-chart recordings; the data are in BCD card images, 50 cards (4,000 characters) per record.

The second file contains BOMEX Marine Meteorological Observations (sec. 1.3.0); the fourth file contains hand-tabulated STD Support Data (sec. 1.7.3); the fifth file contains Radiometersonde Data (sec. 1.1.3.2); the sixth file contains Dropsonde Data (sec. 2.2.3).

As noted above, the third file contains Ship Operations Data. The format is as follows:

Character	Element
1	Card code, should always be 4
2	Ship code
	0 - _Oceanographer_
	1 - _Rainier_
	2 - _Mt. Mitchell_
	3 - _Discoverer_
	4 - _Rockaway_
3-5	Modified Julian day (day of year)
6-7	Hour, GMT
8-9	Minute
10-11	Latitude, degrees
12-13	Latitude, minutes
14	Should always be 1 for north
15-17	Longitude, degrees
18-19	Longitude, minutes
20	Should always be 4 for west
21	Means of navigation
	1 DR
	2 Astro
	3 Omega
	4 Loran A
	5 Loran C
	6 Satellite
	7 Radar
	8 Visual

22-24	True speed, knots to tenths
25-28	True heading, degrees true to tenths
29-31	Indicated speed, knots to tenths
32-45	System status for the last hour 0 - operational 1 - partly operational 2 - nonoperational, reparable 3 - nonoperational, nonreparable
32	Rawinsonde
33	Scanwell
34	Radar wind
35	Boom
36	Surface
37	BLIP
38	STD
39	AEC
40	Niskin
41	Braincon
42	Ship navigation system
43	SCARD
44-45	Not used
46	Sign of ship's gyro correction, plus or minus
47-49	Ship's gyro correction, degrees to tenths

1.5.0 BOMEX FIXED-SHIP EVENT LOG

The BOMEX Fixed-Ship Event Log is a plain-language record kept by the ships' personnel to document the chronology of a day's observational and operational activity. For the inventory of the available data archive products and instructions for ordering, see section 4.0.0, Data Ordering Instructions and Costs.

1.5.1 Contents of the Event Log

The BOMEX Event Log was designed as an aid in verifying the completeness of the data obtained, and all events, whether routine or special, were recorded on it. A new Event Log sheet was begun with each SCARD tape change, several sheets being required for one SCARD analog tape recording period. As the sample in figure 1-12 shows, the Event Log consists of the following:

Heading - Ship's name; day, month, year; and the SCARD magnetic tape number.

Time - Julian Day and hours and minutes in GMT.

Sequential No. - A sequential number assigned to each observation type, starting with 1 and successive numbers thereafter until the end of the BOMEX Observation Period.

Event - Hand-written description of event.

Summary - Checked (✓) by person verifying that the event has been properly entered. An X in this column means that a discrepancy has been found and corrected; an 0 indicates that the discrepancy cannot be corrected, and the problem is then described in the Event column.

Initials - Initials of the observer.

1.5.2 BOMEX Fixed-Ship Event Log Archive Format

The Event Logs are contained in the archive on 35-mm microfilm, arranged by BOMEX Observation Period, i.e., Period I first, followed by Periods II, III, and IV. Within each Observation Period, all the Event Logs for the *Oceanographer* come first, followed by those for the *Rainier*, *Mt. Mitchell*, *Discoverer*, and *Rockaway*.

a. SHIP: DISCOVERER
DATE: 4 MAY 69
MAG.TAPE NO: 1240230

BOMEX EVENT LOG

b. TIME			c. SEQ. NO.	LOG EACH EVENT AS IT OCCURS AND IS REPORTED		
DAY	HOUR	MIN		d. EVENT	e. SUM:	f. INIT:
124	02	30	3	BEGIN SCARD TAPE	✓	TB
124	03	00	32	RAWIN RELEASED	X	TB
124	03	30	3	SCARD INOPERATIVE [EXACT TIME NOT KNOWN]	O	TB

Figure 1-12. BOMEX Event Log.

1.6.0 DISCOVERER WEATHER RADAR PHOTOGRAPHS AND RADAR LOG

Weather radar data were obtained aboard the *Discoverer* from the southeast corner of the BOMEX fixed-ship array by a Selenia radar, Model METEOR 200 RMT-2S, whenever this radar was not being used for rawinsonde balloon tracking.

During weather radar surveillance, 35-mm photographs were taken of the PPI on a VD-2 repeater displaying maximum ranges of up to 200 n mi. The photographs were taken every 12 sweeps for one-sweep exposures (12 sec). In addition, every 30 min, usually, an attenuation-elevation sequence was taken, for which the camera mounted on the VD-2 repeater was set to take one frame every other sweep (rotation of the radar antenna). With the tilt angle held at 0°, the receiver gain was attenuated in calibrated steps. The first step was 15 dB; the remaining steps were 6 dB. The antenna was tilted in 1 or 2° steps at normal receiver gain until all echoes had disappeared. At the conclusion of the altitude sequence the antenna was returned to 0°. For the inventory of available data products and ordering instructions, see section 4.0.0, Data Ordering Instructions and Costs.

1.6.1 Radar Photographic Data

On each roll of 35-mm film the following code is included:

"STC" means STC is on.

Gain attenuation:

dB	3	6	9	12	15	18	21	24	27	30	33
Light	3,4	1,2	1,2,3	1,3	1	1,4	2	2,3	3	2,4	4

If light #5 is on, add 33 dB.

The normal attenuation sequence begins with 15 dB and increases in 6-dB steps until all echoes disappear.

Elevation: Lights 1,2,3,4 are on if elevation is not zero. The normal elevation sequence consists of 1° steps from 0° until all echoes disappear. Before 2230Z, 6/20/69 (Frame #9562), 2° elevation steps were used.

Range: Maximum up to 200 n mi.

On the average, one photograph of weather activity was taken every 144 sec when, as noted earlier, the radar was not used for rawinsonde balloon tracking.

1.6.2 Discoverer Weather Radar Log

This log describes the daily weather radar operations. Each page is labeled with date, data ID code, and page number. A new page was usually begun at the start of each GMT day. Each entry is prefaced by GMT time, frame number, and film roll number. The entries are:

(1) Camera on or off with indication of photograph frequency.

(2) Start to finish of attenuation-elevation sequence.

(3) Change of photograph frequency.

(4) Winding and setting of data chamber clock.

(5) Calibration sequences.

(6) Magazine changes.

(7) Start or stop of precipitation on station.

(8) Hourly synopsis of activity observed.

(9) Error or changes in normal operations procedure.

(10) Any other item the operator felt was significant to the project.

These logs are available in 35-mm microfilm form.

1.6.3 Discoverer Weather Radar Photograph and Radar Log Archive Formats

The radar photographs are archived as registered copies of the original radar film, and the radar logs are archived as microfilm copies of the original hand-written logs. One reel of 35-mm radar photograph film contains approximately 2 days of *Discoverer* radar photographs. The radar logs are arranged in chronological order for Observation Periods II, III, and IV; there are no logs sheets for Period I.

All dates, beginning times, and ending times for each reel of 35-mm radar film in table 4-17, section 4.0.0, are as read from the film by the BOMAP staff. In some instances, these entries may not appear correct, e.g., the time period of radar data does not coincide with the ship operations period. Such anomalies can usually be corrected by the remarks or notes contained in the *Discoverer* Weather Radar Log, described in the preceding section.

1.7.0 STD (SALINITY-TEMPERATURE-DEPTH)SENSOR DATA AND SEA-SURFACE TEMPERATURE DATA

Bissett-Berman salinity-temperature-depth (STD) sensors, Models 9006 and 9040, were used during BOMEX for measuring salinity and temperature of sea water and depth of sensor. The instrument's underwater signals were frequency-multiplexed so that salinity, temperature, and depth measurements were transmitted through the lowering cable as a single composite wave form, which was direct-frequency recorded on SCARD aboard ship. The incoming signal was also separated into salinity, temperature, and depth frequencies, which were strip-chart recorded as a quality control measure and to control operation of the underwater unit. A summary of STD equipment aboard each of the five fixed ships is given in table 1-22.

The observed data archive products consist of processed salinity-temperature-depth data (8-sps STD) and the Radio Transmission Logs for Salinity, Temperature, Depth, and Sound Velocity. (No sound velocity measurements were made.) The STD Support Data contain surface and 1,000-m salinity and temperature information for comparison with the 8-sps data. Two-hourly sea-surface temperature (bucket temperatures) observations are included in the archive. For the inventory of available data products and ordering instructions, see section 4.0.0, Data Ordering Instructions and Costs.

1.7.1 STD Observation Procedures

STD observation procedures during BOMEX on each of the five fixed ships were developed to (a) support the data recording and computer processing of STD data from magnetic tape, (b) insure that all STD data were collected by the same method, and (c) insure that the results from one ship would be consistent with and could be correlated with those from the other ships. These procedures included a two-bottle Nansen cast, physically attached to the STD cable, twice daily (at 0000 and 1200 GMT) for quality control; and reducing and logging sea-surface temperature and STD information for radio transmission to Barbados in support of the oceanographic forecast program on the island (see sec. 1.7.3).

Two basic types of STD observations were made: "Rainy Day" observations for investigation of the influence of rain water on ocean surface water (0 to 15 m) and STD casts to a depth of 1,000 m.

Table 1-22. BOMEX STD sensor characteristics

Ship	STD model number	Sensor input	Range of mesurement System 1 (primary)	Range of mesurement System 2 (backup)
Oceanographer	9006	temperature	-2 to +35°C	-2 to +35°C
		salinity	28 to 38°/oo	30 to 40°/oo
		depth 1	0 to 300 m	0 to 300 m
		depth 2	0 to 2,000 m	0 to 2,000 m
Discoverer	9006	temperature	-2 to +35°C	-5 to +35°C
		salinity	28 to 38°/oo	28 to 38°/oo
		depth 1	0 to 300 m	0 to 300 m
		depth 2	0 to 4,000 m	0 to 4,000 m
Rockaway	9006	temperature	-2 to +40°C	
		salinity	30 to 40°/oo	
		depth 2	0 to 1,500 m	
Rainier	9040	temperature	-2 to +39°C	-2 to +39°C
		salinity	30 to 40°/oo	30 to 40°/oo
		depth 2	0 to 3,000 m	0 to 3,000 m
Mt. Mitchell	9040	temperature	-2 to +39°C	-2 to +39°C
		salinity	30 to 40°/oo	30 to 40°/oo
		depth 2	0 to 3,000 m	0 to 3,000 m

"Rainy Day" STD Observations. This routine began when confirmed precipitation over an area greater than 2 n mi across approached the ship. "Rainy Day" observations were interrupted for the scheduled 1,000-m casts and were resumed after these casts had been completed. Time mark in Julian Day and hours, minutes, and seconds in GMT for the start of the observation and elapsed time since the time mark were recorded on a Rainfall/Salinity (R/S) coding form. Salinity was recorded as an analog frequency on SCARD magnetic tape. In summary, the "Rainy Day" routine consisted of the following steps:

(1) Establishing a level below the surface from which the STD was to be lowered to a depth of 15 m.

(2) Soaking at this starting level and recoding surface salinity on magnetic tape for 5 min.

(3) Taking bucket temperature and salinity, lowering the sensor at a rate not exceeding 10 m/sec, and recording the elaps time to cover 15 m and wire angle during lowering.

(4) Establishing a salinity signature for 5 min at 15 m.

(5) Retrieving sensor to starting level and establishing surface salinity signature for 5 min; taking bucket sample every 30 min.

(6) Repeating steps 4, 3, and 5 and recording the beginning and ending time of each step on the R/S form. (The R/S forms have not been placed in the temporary archive. Copies of the original handwritten forms can be obtained from the BOMAP Office upon request.)

1,000-m STD Observations. Deep STD observations were made from the Discoverer, Oceanographer, and Rockaway eight times per day (0100, 0300, 0600, 0900, 1200, 1500, 1800, and 2100 GMT) and from the Mt. Mitchell and Rainier four times per day (0100, 0600, 1200, and 1800 GMT), within ± 30 min of the scheduled times. For calibration purposes, two Nansen bottles were attached to the STD cable 10 and 15 m from the sensor package during the 0100 and 1200 GMT casts; during all other casts, surface temperature and salinity were determined from a bucket sample. The upper Nansen bottle was tripped at approximately 1,000 m after soaking for 12 min. After it had been brought aboard, the lower bottle was tripped, having soaked for 5 min. The bottle thermometers were read to the nearest hundredths °C, and salinities were determined within ± 0.003°/oo on successive readings by a calibrated salinometer. In summary, the operational sequence was as follows:

(1) Systems check (leaking sensor and sensor connections; proper winch and STD operation; information logged in on STD Observation Form described in section 1.7.3).

(2) Preparing analog strip-chart recorder and SCARD.

(3) Placing the STD in the water; obtaining surface bucket sample.

(4) After a 2- to 5-min soak and logging the appropriate information and timing marks, lowering the STD package at a rate of 20 m/min for the first 100 m and at a higher rate down to 1,000 m; annotating during lowering the scale changes on the analog recorder, along with the wire angle and timing and event marks that would assist in documenting the STD observation program. (These lowering rates were not always adhered to and were often higher than specified.)

(5) Terminating the cast at 1,000 m. When Nansen bottles were attached, a messenger was sent down to trip the upper bottle.

(6) Retrieving the cast; tripping the lower Nansen bottle (if attached) and bringing package aboard.

1.7.2 STD 8-sps Data Reduction and Processing

The STD output was recorded as mixed analog frequencies on one channel of the seven-channel tape recorder contained in SCARD. The

frequencies of the signals varied from 1.5 kHz for the low-range depth signals to slightly over 10 kHz for the high-range depth signals. In addition, a reference signal of 3.125 kHz was recorded on another channel for tape speed control during playback.

1.7.2.1 Digitization

The SCARD analog tapes were digitized at NASA's Mississippi Test Facility (NASA/MTF). The analog tapes were played back at the nominal recording speed of 1 7/8 ips (inches per second) on one of the SCARD decommutation tape transports. The composite STD signal, the 3.125-kHz reference signal, and the AMRB1 (Atlantic Missile Range B-1 Time Code) time signal were filtered and then inputed to a Beckman Model 420 computer via the Beckman Model 210 data acquisition system for digitization. The tape speed on playback was controlled by a velocity servo that provided for relatively low tape speed accelerations. Exact correction for instantaneous tape speed changes was provided computationally (see sec. 1.7.2.2).

Figure 1-13 shows the signal conditioning, separation, and shaping which was used between the SCARD unit and the Beckman 210 data acquisition system. The bandpass filters are identical to those used in the Bissett-Berman Model 9040 or 9006 deck unit. These have been augmented with SKL (Spencer Kenedy Laboratories, Inc.) Model 308A (24 dB/octave), and Model 302 (18 dB/octave) active filters operated in the high-pass mode with cutoff frequencies as shown. The filter outputs were passed to the Tektronix oscilliscope amplifiers that also provided a visual indication of signal level and noise content. The trigger outputs of these amplifiers, overdriving the Dana Model 2200 D.C. amplifiers, provided a heavily clipped signal of about 2 v PP to drive the period counters. The 3.125-kHz reference frequency was amplified and clipped before being counted. The AMRB1 time code was converted to a bipolar signal by the 5.4-kHz discriminator and introduced into the computer, where it was decoded by an analog-to-digital converter that is part of the Beckman system.

STD signals from the amplifier outputs were counted in the so-called "flow counters" in the Beckman Model 210 data acquisition system. A separate counter was used for each signal. Figure 1-14 shows the counter hardware arrangement. Figure 1-15 shows system timing during a typical counting operation. The Schmidt trigger has a dead band of about 2 v PP around zero volts, which gives some noise immunity without noticeably affecting sensitivity, since the signal at this point is usually $\sim$20 v PP. The trigger output is synchronized with the system's 250-kHz clock so that a pulse one clock-period long is produced for every negative-going zero crossing in the input signal. This reduces the resolution of the system to 4 μsec despite the fact that a 1-μsec clock is subsequently counted. This was unavoidable because major rework in the system logic would have been required to substitute a 1-MHz clock.

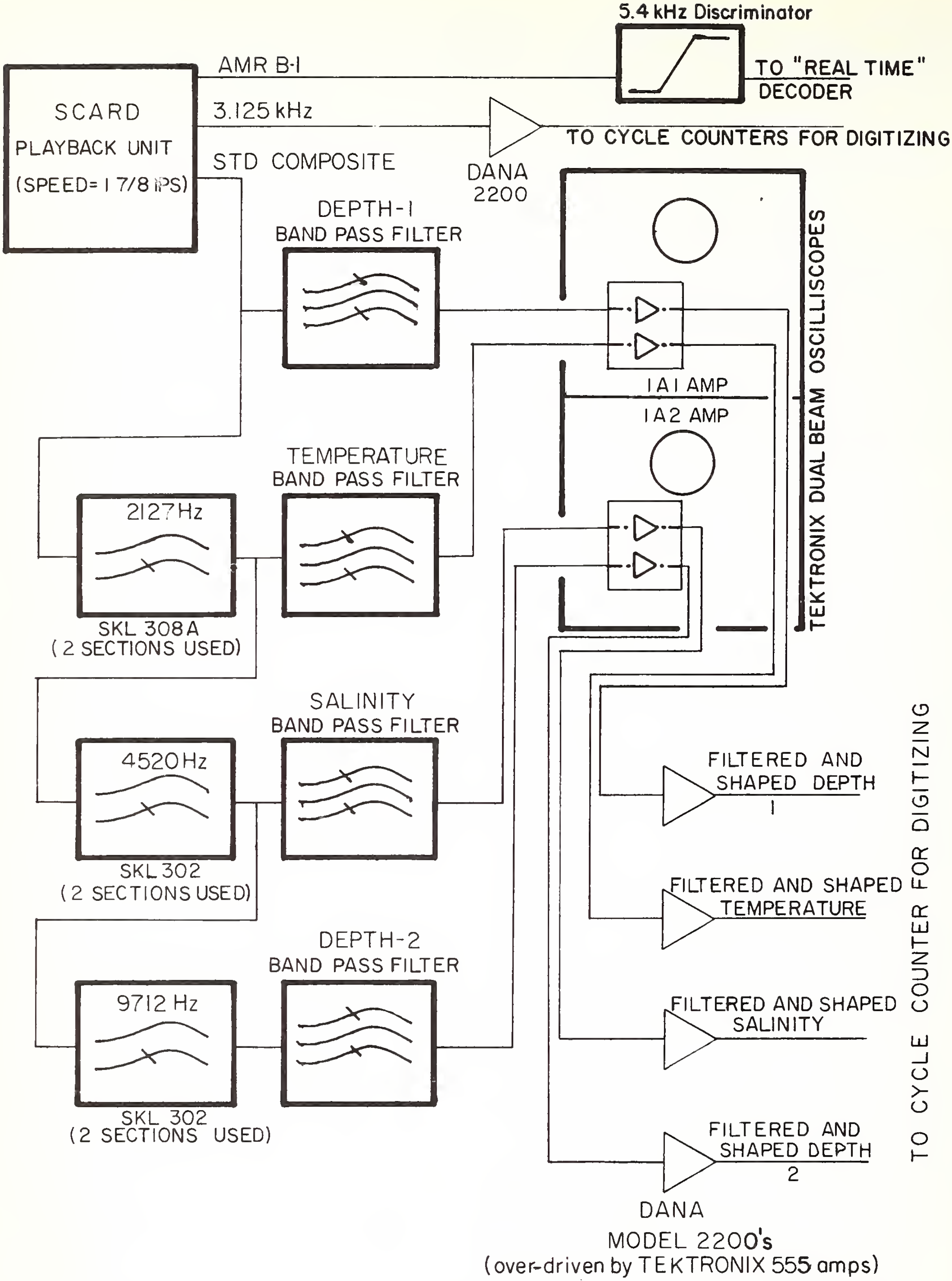


Figure 1-13. Separation and signal conditioning of the recorded signal prior to input for digitization.

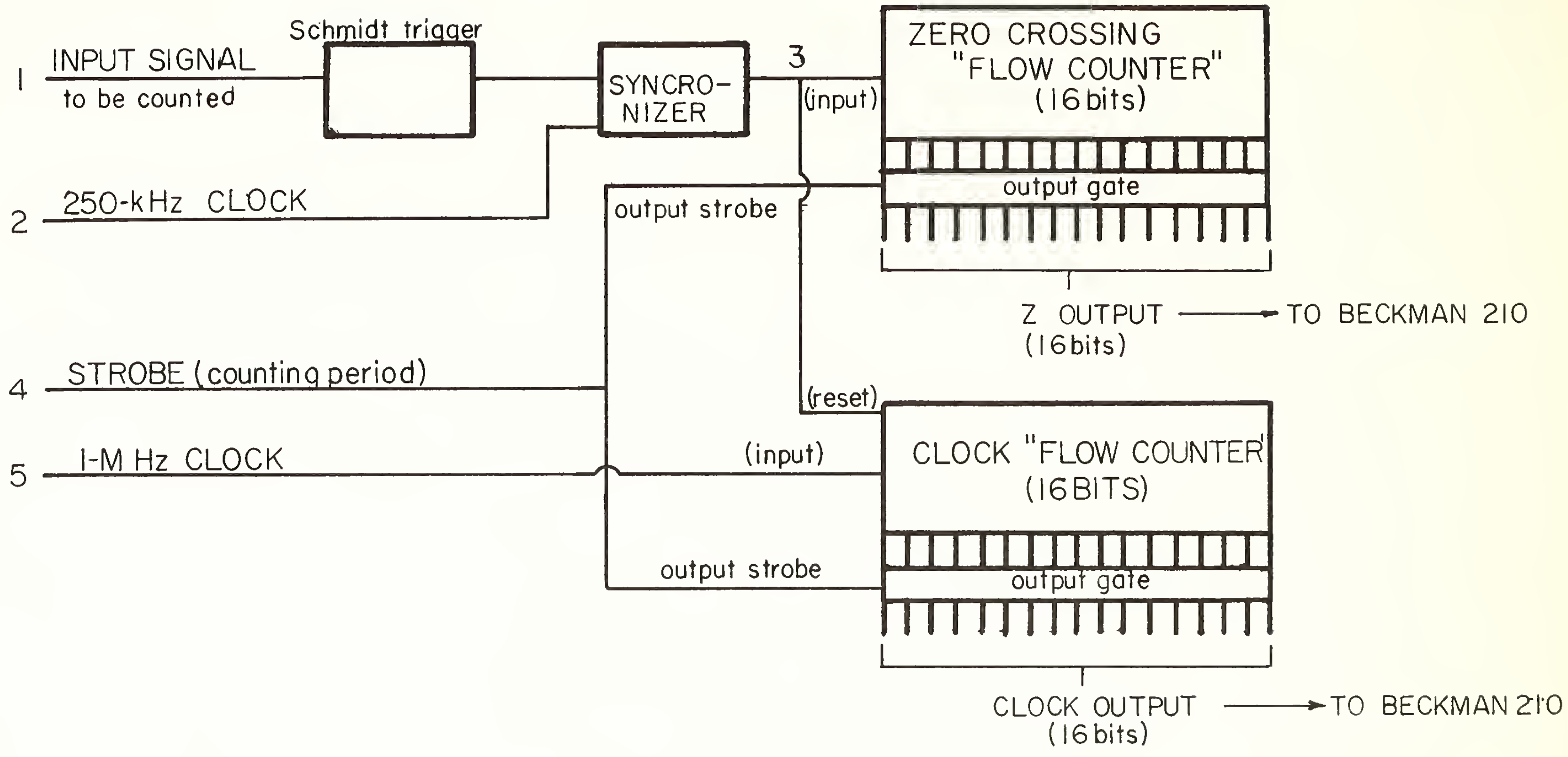


Figure 1-14. Flow counter hardware arrangement.

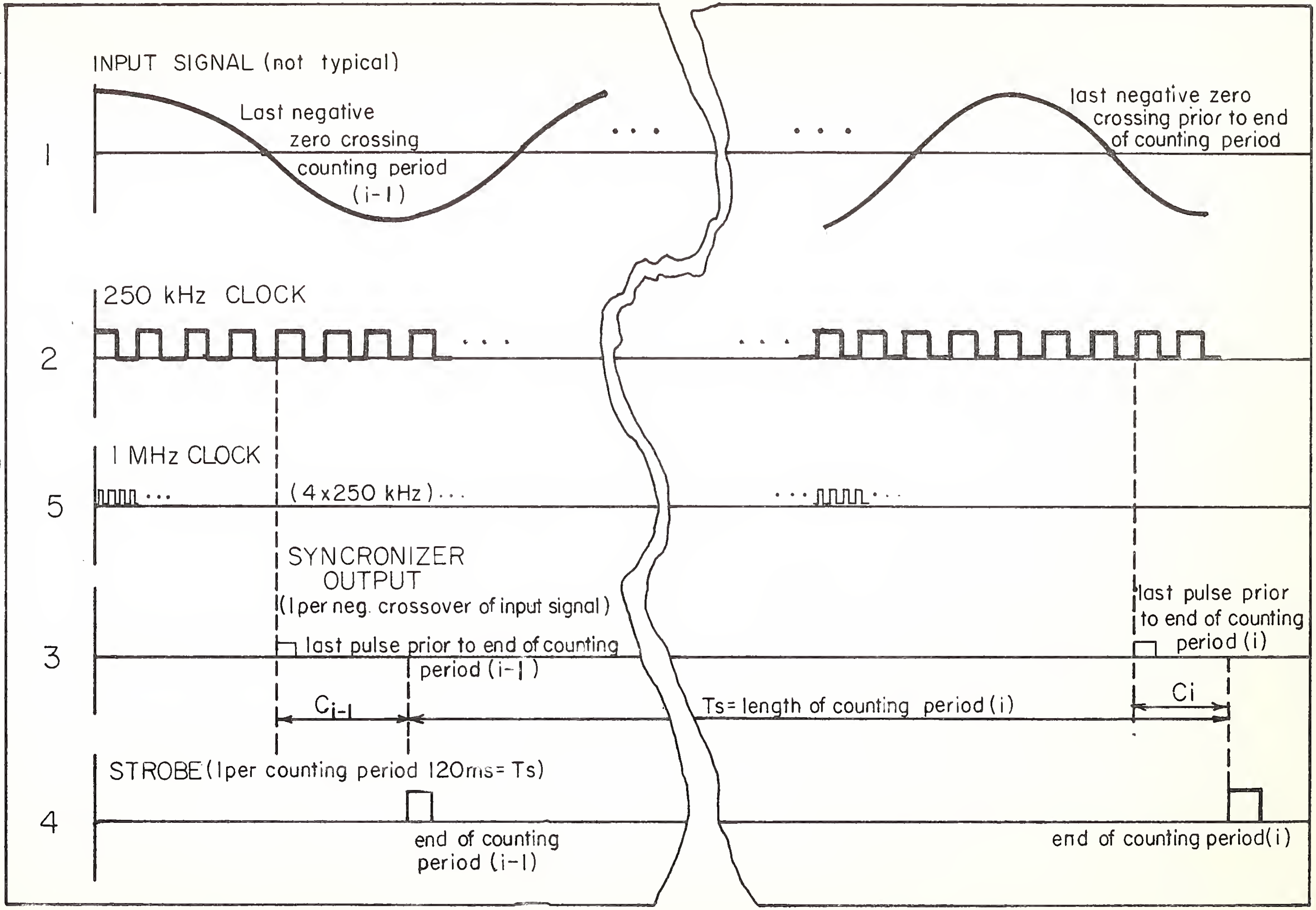


Figure 1-15. Input waveforms and system timing during a typical counting operation.

The pulses generated by the synchronizer served two purposes. They were counted in the zero crossing counter, which keeps track of the total number of cycles of the signal being measured. This counter was not reset and was allowed to overflow to zero as necessary. The pulse generated by the synchronizer were also used to reset the clock period accumulated so that it always contained the number of clock pulses that had occurred since the last zero-crossing pulse. Both counters were strobed into the data acquisition system's output buffer whenever an output pulse occurred, in which case it occurred synchronously with one of the 250-kHz clock pulses but asynchronously with the zero crossings of the input signal.

Defining the terms

T_s = the time between output pulses in microseconds,

$Z_{(i-1)}$ = count in zero-crossing register at output pulse i-1,

$Z_{(i)}$ = count in zero-crossing register at output pulse i,

$C_{(i-1)}$ = count in clock period accumulator at output pulse i-1, representing the time in microseconds since the last zero-crossing pulse, and

$C_{(i)}$ = count in clock period accumulator at output pulse i,

we obtain for the measured frequency F_i, in hertz, of the signal during the interval between output pulses i-1 and i:

$$F_i = \frac{Z_i - Z_{(i-1)}}{(T_s + (C_{i-1} - C_i) \times 10^{-6}} .$$

Because of the synchronism, $C_i = 0_{\text{MODULUS } 4}$.

Because of design constraints of the Beckman data acquisition system, it was not possible to have the counting periods for all signals start and stop simultaneously. The system imposed a minimum of 100-μsec separation between adjacent channels and the nature of the counter adds a random variation that may be as much as one cycle of the signal. In the worst case as much as 1 percent of the counting period may not be common to any two signals. From an oceanographic standpoint, this is not important and the measurements may be considered simultaneous. However, it may affect the tape speed correction (see sec. 1.7.2.2).

The above computation for frequency was made in the Beckman 420 computer, which uses an 18-bit word. Because of this, the term $(T_s+C_{i-1}-C_i)$ must be less than 131071 (i.e., $2^{17}-1$). The fact that the unit of measure is microseconds and the basic cycle of the acquisition program is 40 msec sets the value of T_s at a maximum of 120 msec. This value was chosen because it yields maximum resolution. The computation was carried out so that the least significant bit in the frequency represented .1 Hz. (Dictated by the word size of the machine.)

Table 1-23 shows the resolution of the system in terms of both frequency and parameter at the maximum frequency for each measured STD parameter, based on a change of 4 μsec in the quantity $C_{i-1} - C_i$ (the minimum detectable change). If ΔF is less than .1 Hz, .1 Hz is used as the effective resolution.

Table 1-23. Digitizing resolution

Measured STD parameter	Maximum frequency (F) of measured parameter (Hz)	ΔF corresponding to a 4- μsec change in $C_{i-1} - C_i$ at F (Hz)	Resulting Δ parameter in scientific units
Salinity	7,901	0.26	0.0009 PPT
Temperature	4,193	0.14	0.0025 °C
Depth 1	1,956	0.06 (0.1)	0.13 decibars
Depth 2 (1,500 m)	11,288	0.38	0.36 decibars
Depth 2 (2,000 m)	11,288	0.38	0.48 decibars
Depth 2 (3,000 m)	11,288	0.38	0.72 decibars
Depth 2 (4,000 m)	11,288	0.38	0.96 decibars

1.7.2.2 Conversion and Processing

The MTF digitized 8-sps magnetic tape data were sent to the BOMAP Office for further processing. They total 134 tapes, containing frequencies analogous to salinity, temperature, and pressure, and a time track and tape-speed control track, with each tape covering 4 to 20 casts. These data were processed through the following three-step data reduction sequence:

PASS 1 Program. At BOMAP, each MTF tape is read by the PASS 1 Program, a Fortran program written for the CDC 6600 Computer, which does the following:

(1) reads and reproduces all header information;

(2) obtains sensor serial number and calibration data based on the header information;

(3) unpacks the MTF records and converts the frequencies to salinity, temperature, and pressure, compensating for tape-speed variations;

(4) identifies the beginning and end of each cast;

(5) filters the temperature and depth signals to remove the effects of quantizing noise;

(6) inspects the data to flag unlikely rates of change in the parameters; and

(7) provides an output tape for further processing.

The basic philosophy in designing the PASS 1 Program was to avoid any operations on the data that could not be justified in terms of either the physics of the STD instrument or the characteristics of the recording and digitizing system. As a result, the final data should represent the true ocean environment, modified only by the transfer function of the STD.

Several processes were used to compensate for deficiencies in the recording and digitizing system. The first of these processes compensates for variations in tape speed during playback. As mentioned in section 1.7.2.1, a 3.125-kHz tone was recorded on the SCARD tape and included as an output quantity of the digitization. Had the playback speed been exactly the same as the original recording speed, all measurements of this signal would have been exactly 3125.0 Hz. The ratio between output value and 3.125 gives the deviation in tape speed for a given sample; thus for all parameters,

$$F_{true} = F_{measured} \times \frac{3125.0}{F_{control\ track}} .$$

If the measurement periods were exactly synchronous, the correction would be perfect. However, since exactly synchronous counting periods were not possible, it was necessary, as noted in section 1.7.2.1, to minimize tape accelerations by the use of the velocity servo on the playback and avoid the use of capstan phase lock.

The second process was the application of a digital filter to the depth and temperature signals. As noted above, the resolution of the digitization of Depth 2 varies between 0.36 and 0.96 decibars. Inspection of the depth signals after the control track correction had been applied showed a scatter band of about 2 decibars. Since the STD will move only 0.12 decibars in one sample interval (at 60 m/min), this is unsatisfactory. A double-running mean filter was chosen that passes periods of 4 sec or more with a response of 98 percent of more while reducing the scatter by a factor of 35. The cutoff is thought to be high enough to pass all significant package motions induced by ship or wave motion without attenuation. Inspection of the temperature trace in isothermal regions also showed evidence of noise on the order of 0.005°C that appeared to be inconsistent with the time constant of the temperature probe ($\approx$ 300 msec) and a three-point running mean filter was applied to the temperature signal. The effect of this filter is practically unnoticeable in areas of high temperature gradient.

Cast detection was incorporated into the PASS 1 Program to identify the start and end of a cast. A cast is considered to have started when the STD is in the water and the temperature and salinity values are as would be expected for 5 sec or more. A cast is terminated approximately 10 sec after the 1,000-decibar point is crossed or when end-of-file occurs on the MTF tape. Records of the salinity, temperature, and pressure values at the surface and at 1,000 decibars are produced automatically for comparison with the Nansen and bucket values.

The detection of noise in the data is one of the major functions of the PASS 1 Program. To a large extent, it has proven possible to discriminate true noise (i.e., electrical interference, cable snaps, tape dropouts, etc.) from ocean phenomena, such as sharp wave motion, step changes in temperature, etc. The filter routine includes two checks for noise. For each point filtered, P_F, a point is added to the filter series at a distance ahead determined by the width of the filter. This point is tested against the following criteria:

P_{F-1} = the previous filtered point.

P_T = the point being tested.

σ = the standard deviation of the unfiltered points in the region of P_F (computed for the previous frame of 20 points and used during this frame),

n_1 = the number of points between P_{F-1} and P_T,

n_2 = the number of consecutive points that have been rejected, and

ΔP = the maximum variation considered reasonable between P_F and P_{F+1} .

If

$$\left|P_{F-1} - P_T\right| \leq 4\sigma + (n_1 + n_2^2)\ \Delta P,$$

then,

$n_2 = 0$; compute P_F using P_T,

otherwise,

add 1 to n_2;

substitute P_{T-1} for P_T; and

plot frame containing error and surrounding frames.

The n_2^2 term prevents lockup in the event of a long series of unexpectedly large changes in P. ΔP values of 0.4 decibars (200 m/min) for pressure and 0.15°C for temperature have been used with good results. All substituted points cause a page printer plot of at least 20 points on either side of the substitution for inspection by BOMAP. The values of the rejected and substituted points are printed along with a message.

After filtering, a test is made to see if $|P_F - P_{F+1}| \leq \Delta P$. If not, a message is printed and a plot is created. The salinity and time signals, which are not filtered, are tested similarly. ΔP for salinity is about

$0.15^{o}/oo$. These tests set a maximum limit for noise in the output that will not be called to attention in the subsequent EDIT Process, discussed below. Since electrical noise often affects all parameters, only one parameter caught by the PASS 1 program leads to inspection of all parameters during the EDIT Process.

EDIT Process. Plots and error messages produced by the PASS 1 Program are inspected by editors who have the following options:

(1) delete the bad point or points from the cast:

(2) interpolate across the bad point or points;

(3) make a linear transformation on the entire cast;

(4) make a linear transformation on several points; or

(5) alter or add header information.

Steps (2) - (4) are applied to individual parameters. The usual procedure is to delete only at the beginning or end of the cast. Interpolations are visually restricted to one or two points, primarily pertaining to salinity, since the corresponding points in temperature and pressure are substituted by the filter routine in the PASS 1 Program. If there is strong evidence of calibration shift, the calibrations may be altered. This is seldom done except for pressure, which sometimes shows negative values during the soak period at the beginning of a cast. When this occurs, the pressure offset is adjusted to force the soak depth to approximately 2 m and a comment is added to the header. Comments are also inserted to call attention to inoperative or excessively noisy sensors or to any other unusual feature noticed by the editor.

Further Processing. The output of the EDIT Process is considered a final time-series tape, with all series noise removed and with headers containing accurate time, position, and calibration information. No effort has been made so far to compensate for salinity spikes or other sensor transfer characteristics, although there are several programs at BOMAP that will do this and produce either time or depth series. These routines will be described in a separate publication. The EDIT output tapes are reformated and converted to BCD to provide the 8-sps STD archive tapes.

1.7.2.3 STD 8-sps Data Archive Magnetic Tape Format

Tapes are written in binary coded decimal (BCD) notation, even parity, 1,600 characters per record. Each file contains records for one STD cast. A double end-of-file mark follows the last file on a tape. Tape density is 556 bits per inch (7 track).

The first record (see fig. 1-16) for each cast contains one card image (80 characters) of fixed-format information about the cast and 19 card

Page 1 of 3

Analyst: Phil Hadsell
Code: ND 31 Date: Dec. 24, 1970

RECORD DESCRIPTION

FILE NAME: BOMAP STD cast RECORD NAME:

RELATION OF RECORD TO THE FILE: First record in the file

ELEMENT NAME AND LEVEL	LOCATION Position	LOCATION Units	LENGTH Number	LENGTH Units	REPEAT FACTOR	ATTRIBUTES: TYPE, BASE, MODE, LANGUAGE, PRECISION, ETC.	USAGE AND MEANING OF ELEMENT	CONDITIONS
Info	1	byte	80	byte	20	BCD, 6 bit byte	20 card images of information relating to the following records of STD data	556 BPI Total record Length 1600 bytes
IRG								

Figure 1-16. First record for STD cast.

images of additional information. Some card images may be blank. The format of the first card image is as follows (see fig. 1-17):

Position	Data	Format
1	Carriage control character	I1
2	"BOMEX STD"	10H
12	Ship name, left adjusted	14H
26	"YEAR"	4H
30	Year	I5
35	"DAY"	4H
39	Modified Julian day, day of year (starting time)	I4
43	"TIME"	5H
48	Hour of start of cast	I3
51		1X
52	Minute of start of cast	I2
54	"GMT"	4H
58	"LAT."	5H
63	Latitude, degees	I2
65		1X
66	Latitude, minutes	I2
68	Direction of latitude, always "N"	1H
69	"LON."	5H
74	Longitude, degrees	I3
77		1X
78	Longitude, minutes	I2
80	Longitude direction, always "W"	1H

Page 2 of 3

Analyst:
Code: Date:

RECORD DESCRIPTION

FILE NAME: BOMAP STD cast RECORD NAME: First card image of header record

RELATION OF RECORD TO THE FILE: Header record is first record of file

ELEMENT NAME AND LEVEL	LOCATION Position	LOCATION Units	LENGTH Number	LENGTH Units	REPEAT FACTOR	ATTRIBUTES: TYPE, BASE, MODE, LANGUAGE, PRECISION, ETC.	USAGE AND MEANING OF ELEMENT	CONDITIONS
	1	byte	1	byte	1	BCD, I 1	Carriage control character "1"	
	2		10		1	10 H	"BOMEX STD "	
	12		14		1	14 H	Ship name, left adjusted	
	26		4		1	4 H	"YEAR"	
	30		5		1	I 5	Year	
	35		4		1	4 H	" DAY"	
	39		4		1	I 4	Modified Julian Day; day of year	
	43		5		1	5 H	" TIME"	
	48		3		1	I 3	Hour of start of cast	
	51		1		1	1 X	Spacer	
	52		2		1	I 2	Minute of start of cast	
	54		4		1	4 H	" GMT"	
	58		5		1	5 H	" LAT "	
	63		2		1	I 2	Latitude, degrees	
	65		1		1	1 X	Spacer	
	66		2		1	I 2	Latitude, minutes	
	68		1		1	1 H	Direction of latitude (always "N")	
	69		5		1	5 H	" LON "	
	74		3		1	I 3	Longitude, degrees	
	77		1		1	1 X	Spacer	
	78		2		1	I 2	Longitude, minutes	
	80	byte	1	byte	1	1 H	Longitude direction (always "W")	

Figure 1-17. Format of STD first card image.

Remaining card images in the header records (there may be more than one item per card) contain the following:

Description of data records.

Instrument model number.

Instrument serial number.

Transfer equation for sensors.

Serial numbers for sensors.

Transfer constants for sensors.

Units output by the transfer equation with constants as given.

The data records (see fig. 1-18) contain data for 100 scans each. The format is 100 (I6,2I5). The elements are: pressure in millibars, salinity in parts per million, and temperature in thousandths °C. Zero-fill is used in the final record of each cast.

The time of the first data scan is assumed to be at 0 sec of the hour and minute given in the first card image of the header record. Successive scans are 0.120 sec apart.

1.7.3 STD Support Data and Archive Format

An STD Observation Form (see fig. 1-19) was used for logging the information necessary for identifying and reducing the STD data recorded on SCARD.

The entries on this form are as follows:

Card Code - Column 1. Code 3.

Ship Code - Column 2. The following codes were entered to identify the ship from which observations were made: Oceanographer - 0, Rainier - 1, Mt. Mitchell - 2, Discoverer - 3, and Rockaway - 4.

Descent Time - Columns 3 through 9. Julian Day, followed by GMT hour and minute of the beginning of an STD observation.

STD Sensor Identification - Columns 10 through 19. 9006 (for Bisset-Berman Model No. 9006) was entered in columns 10 through 13 if the platform used was the Oceanographer or Discoverer; 9040 (for Bissett-Berman Model No. 9040) was used for the Rockaway, Mt. Mitchell, and Rainier. Sensor serial number on the body of the mounting frame for the sensors was indicated in columns 14 through 19.

Page 3 of 3

Analyst: ______
Code: ______ Date: ______

RECORD DESCRIPTION

FILE NAME: BOMAP STD cast RECORD NAME: Data Record

RELATION OF RECORD TO THE FILE: One of approximately 100 records within the file

ELEMENT NAME AND LEVEL	LOCATION: Position	LOCATION: Units	LENGTH: Number	LENGTH: Units	REPEAT FACTOR	ATTRIBUTES: TYPE, BASE, MODE, LANGUAGE, PRECISION, ETC.	USAGE AND MEANING OF ELEMENT	CONDITIONS
Pressure	1	byte	6	byte	100	BCD, 6 bit byte	Milli bars	556 BPI
Salinity	7	byte	5	byte	100	" "	Parts per million	
Temperature	12	byte	5	byte	100	" "	Thousandths of degrees Celsius	
IRG							Record length 1600 bytes	
	Repeat as necessary						Zero fill in last record of file	
IRG								
EOF	Files repeated as necessary							
EOF	After last STD file on tape					(Double	EOF after last file)	

Figure 1-18. STD data record.

STD OBSERVATION FORM

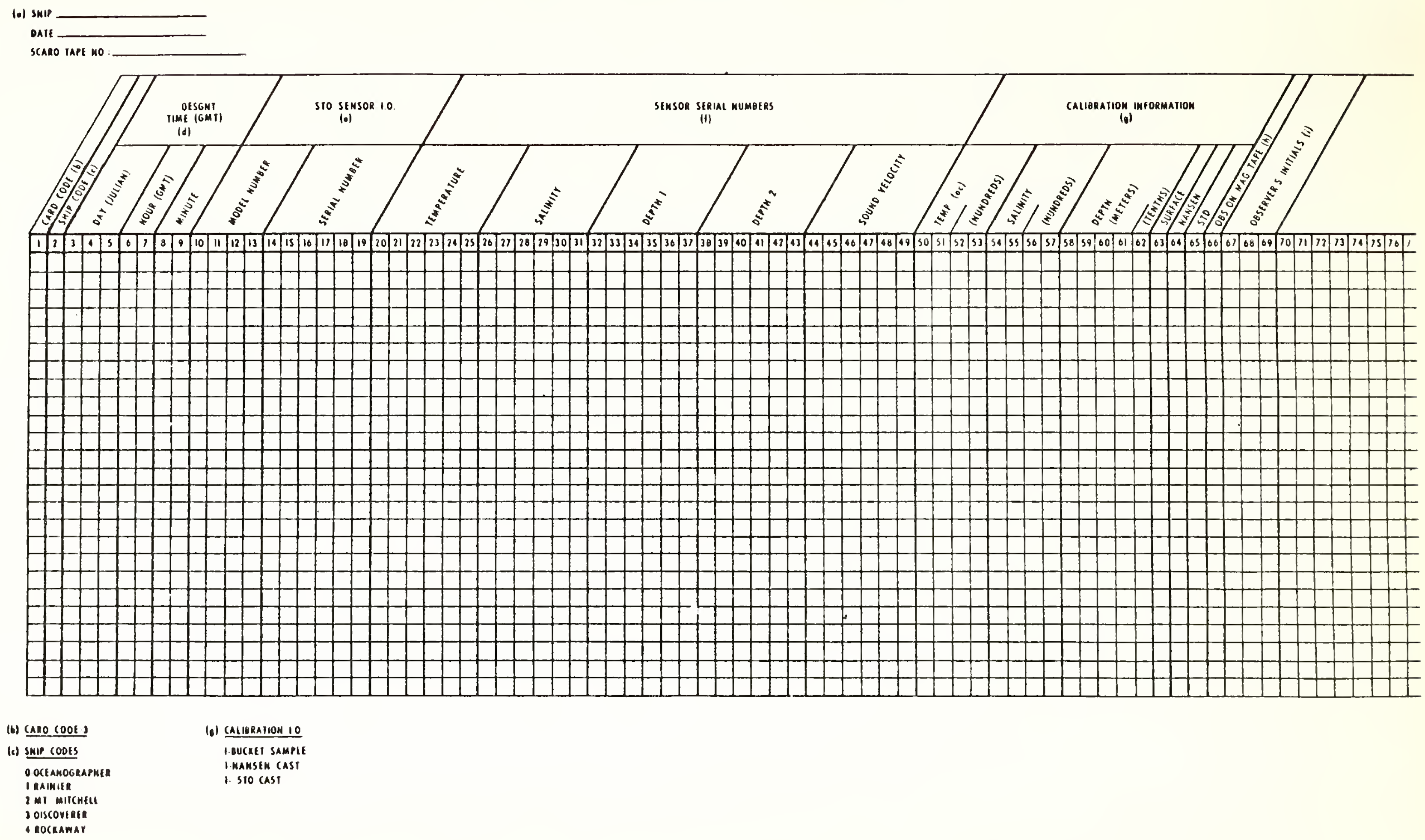


Figure 1-19. STD Observation Form.

Sensor Serial Numbers - Columns 20 through 49. Serial numbers of temperature and salinity sensors were recorded in columns 20 through 25 and 26 through 31, respectively. Columns 32 through 37 indicate serial number of sensor cast to Depth 1 (0 to 300 m from the *Oceanographer* and *Discoverer*) and Depth 2 (0 to 200 m from the *Oceanographer*, 0 to 4,000 m from the *Discoverer*, 0 to 1,500 m from the *Rockaway*, and 0 to 3,000 m from the *Rainier* and *Mt. Mitchell*).

Sound Velocity - Columns 44 through 49. Not entered, since neither of the STD models carried sound-velocity sensors.

Calibration Information - Columns 50 through 65. Temperature to a precision of hundredths of °C was entered in colums 50 through 53; salinity in parts per thousands to the hundredth part in columns 54 through 57; and depth in meters and tenths in columns 58 through 62. To indicate the source of sample (surface bucket sample, Nansen cast, or STD cast), 1 was entered in the appropriate column (63, 64, or 65).

Observations Recorded on SCARD Magenetic Tape - Column 66. If at the conclusion of the STD observation, the SCARD team had confirmed successful magnetic-tape recording, 1 was entered in column 66.

Observer's Initials - Columns 62 through 69. The STD team leader's initials after check of completeness of the observation.

The magnetic tape format consists of six separate files, of which the fourth one constitutes the STD Support Data. When these data on magnetic tape are requested, all six files will be sent, not the STD Support Data alone. The six files of information on this tape are separated from each other by end-of-file mark and followed by a double end-of-file. All information is in binary-coded-decimal (BCD) format, even parity, 800 bits per inch. The first file consists of 80-colum card images, one card image per record, describing the formats of the data files. The other five contain data that were either recorded manually or were read manually from strip-chart recordings; the data are in BCD card images, 50 cards (4,000 characters) per record.

The second file contains BOMEX Marine Meteorological Observations (sec. 1.3.0); the third file contains Ship Operations Data (sec. 1.4.0); the fifth file contains the Radiometersonde Data (sec. 1.1.3.2); the sixth file contains Dropsonde Data (sec. 2.2.3).

As noted above, the hand-tabulated STD Support Data constitute the fourth file. The format is as follows:

Character		
1		Card code, should always be 3
2		Ship code
		0 - _Oceanographer_
		1 - _Rainier_
		2 - _Mt. Mitchell_
		3 - _Discoverer_
		4 - _Rockaway_
3-5		Modified Julian day (day of year)
6-7		Hour, GMT
8-9		Minute
10-13		STD model number
14-19		STD instrument package serial number
20-25		Temperature sensor serial number
26-31		Salinity sensor serial number
32-37		Depth 1 sensor serial number
38-43		Depth 2 sensor serial number
44-49		Sound velocity sensor serial number
50-53		Calibration temperature, degrees Celsius to hundredths
54-57		Calibration salinity, parts per thousand to hundredths
58-62		Calibration depth, meters to tenths
63-65		Indicators for type of calibration data
		1 - used
		0 - not used
	63	Bucket sample
	64	Nansen cast
	65	STD cast
66		1 if observation recorded on magnetic tape 0 if observation not recorded on magnetic tape

1.7.4 Radio Transmission Log for STD Observations and Archive Format

A Radio Transmission Log for Salinity-Temperature-Depth (STD) and Sound Velocity Data was used for transmission of STD data to Barbados twice daily to support up-to-date forecasts for use in the BOMEX area. After the 0000, 0600, 1200, and 1800 GMT observations had been logged and checked, the data were transmitted to the island.

As the sample log in figure 1-20 shows, across the top the following was entered: ship's name and code (*Oceanographer* - 0, *Rainier* - 1, *Mt. Mitchell* -- 2, *Discoverer* - 3, *Rockaway* - 4); country (USA); institute (BOMEX); cruise number (BOMEX Field Observation Period 1, 2, 3, or 4); station number (A - ALFA, B - BRAVO, C - CHARLIE, D - DELTA, or E - ECHO); and sheet number (sheet 1 representing the first STD observation and numbered sequentially thereafter).

Under Radio Message Information, the following is indicated: ship's international radio call sign; a message indicator (in each case HISTD); day represented by numerals 01-31; month represented by numerals 01-12; and year represented by the last two digits (69 for 1969); the time at which observation began in GMT hour and minute; quadrant (7 for the BOMEX area); and latitude and longitude in degrees and minutes. Depth to bottom was left blank and no environmental information was carried.

Under Radio Message Data, the symbols 2, 3, 4, and 5 running vertically were radio transmitted to identify each group. Sound velocity data were not recorded. When observations were not made to the significant digit provided for on the log, a zero was entered and transmitted. Depths were recorded at 0, 10, 20, 30, 50, 70, 100, 125, 150, 200, 300, 400, 600, 800, and 1,000 m. Surface temperature was recorded to a precision of hundredths of °C. Salinity was entered in parts per thousands to the nearest hundredth part.

The log sheets are reproduced on 35-mm microfilm for distribution from the archive. These data (one sheet per STD cast) for four casts per day during all BOMEX Observation Periods are being supplied in lieu of the missing BOMAP 8-sps STD data. The procedure for selecting the data points from strip charts or STD plots was in accordance with standard National Oceanographic Data Center (NODC) instructions for this log.

The log sheets are organized by BOMEX Observation Period, i.e., Period I first, followed by the sheets for Periods II, III, and IV. Within each period, all the sheets for the *Oceanographer* come first, followed by those for the *Rainier*, *Mt. Mitchell*, *Discoverer*, and *Rockaway*.

RADIO TRANSMISSION LOG FOR SALINITY, TEMPERATURE, DEPTH, AND SOUND VELOCITY DATA

SHIP	COUNTRY	INSTITUTE	CRUISE NO.	STATION NO.	SHEET NO.
OCEANO - O	USA	Bomex	#1	B	1

RADIO MESSAGE INFORMATION

1 SHIPS CALL SIGN	2 MESSAGE INDICATOR (H I S T D)	3 DAY-MONTH-YEAR (D D M M A)	4 TIME (GMT) (A G G g g)	QUAD (Q_c)	5 LATITUDE (DEG. MIN 1/10)	6 LONGITUDE (DEG. MIN 1/10)	7 DEPTH (M) TO BOTTOM
WTEP	~~ ~~	03056	90600	7	1736	05434	

ENVIRONMENTAL INFORMATION

1 CAST	2 WAVES (DIR, PER, HT)	3 WIND (DIR, SPEED)	4 BAR. PRESS (MBS)	5 AIR TEMP. °C °F (DRY BULB, WET BULB)	6 WEATHER	7 VIS.	8 CLOUD (TYPE, AMT)	9 DURATION (HR, 1/10)
U/D								

RADIO MESSAGE DATA

DEPTH 2ZZZZ	TEMPERATURE 3TTTT	SALINITY 4SSSS	SOUND VEL. 5VVVV	DEPTH 2ZZZZ	TEMPERATURE 3TTTT	SALINITY 4SSSS	SOUND VEL. 5VVVV	DEPTH 2ZZZZ	TEMPERATURE 3TTTT	SALINITY 4SSSS	SOUND VEL. 5VVVV
2 0000	3 19.92	4 36.69	5	2 0010	3 19.92	4 36.69	5	2 0020	3 19.92	4 36.69	5
2 0030	3 19.92	4 36.69	5	2	3	4	5	2 0540	3 16.22	4 36.22	5
2	3	4	5	2 1400	3 04.73	4 35.03	5	2 1420	3 04.69	4 35.03	5
2 1440	3 04.62	4 35.05	5	2 1464	3 04.51	4 35.03	5	2 1500	3 04.67	4 35.07	5 1991
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5
2	3	4	5	2	3	4	5	2	3	4	5

END OF MESSAGE INDICATOR: 19991

REMARKS:

NDW-NODC-3167/43 (7-68)

Figure 1-20. Radio Transmission Log for Salinity, Temperature, Depth, and Sound Velocity Data.

1.7.5 Naval Oceanographic Office "C" Temperature Log and Archive Format

A standard NAVOCEANO CTEM Sea-Surface Temperature Log designed for radio transmission was used for manual recording of sea-surface temperature on a routine basis every 2 hours, based on bucket thermometer readings. Two forms were required for the twice-daily radio transmissions, one for the 0100, 0300, 0500, 0700, 0900, and 1100 GMT observations, and the other for the 1300, 1500, 1700, 1900, 2100, and 2300 GMT observations. Code B was used to indicate bucket thermometer reading, followed by date, quadrant (7 for the BOMEX area), latitude and longitude, scheduled hour of observation (preprinted), and sea-surface temperature to the nearest tenth of °C. End of each observation period was indicated by 19991.

The archive products consist of 35-mm microfilm reproductions of two sheets of the original NAVOCEANO CTEM Log for each BOMEX observation day. The sheets are organized by BOMEX Observation Period, i.e., all sheets for Period I first, followed by those for Periods II, III, and IV. Within each Observation Period, all sheets for the *Oceanographer* come first, followed by those for the *Rainier*, *Mt. Mitchell*, *Discoverer*, and *Rockaway*.

2.0.0 BOMEX AIRCRAFT-ACQUIRED DATA

Data from the following aircraft have been processed for the temporary archive: DC-6 and DC-4 aircraft of the Research Flight Facility (RFF), ESSA (now NOAA); WC-121 weather reconnaissance aircraft operated by the Navy VW-4 Squadron; and WB-47, RB-57, and WC-130 aircraft operated by the Air Weather Service, U. S. Air Force. Special call signs and designators for the aircraft, used in BOMEX data logs and in the archived data, are identified in table 2-1. Table 2-2 lists the fixed reporting points used to facilitate mission briefing, operational control, and reporting of aircraft position.

In support of the Sea-Air Interaction Program, or BOMEX Core Experiment, line integral missions were flown by the RFF DC-6 and DC-4 and Navy WC-121 aircraft around the periphery of the BOMEX volume, delineated by the 500- by 500-km array formed by the five ships occupying fixed positions at the corners and in the center of the square (see sec. 1.0.0, fig. 1-1). These missions were flown to obtain data for evaluating the budgets of mass, momentum, water vapor, and total energy for the BOMEX volume.

The line integral patterns can be grouped as follows:

Day line integral patterns (LID A and LID B)

Night line integral patterns (LIN, LIN MOD 1, and LIN MOD 2)

Multiple-level day and night line integral patterns
(LID C, D, E, F, and G; LIN C, D, and E)

Table 2-3 identifies the days on which these missions were flown. The various tracks are illustrated in <u>BOMEX Field Observations and Basic Data Inventory</u> (in press), issued by the BOMAP Office. The basic observation system carried aboard each of the RFF aircraft is described in table 2-4, and the recording systems are listed in table 2-5. Tables 2-6 and 2-7 provide information on the basic observation systems and meteorological instrumentation aboard the Navy WC-121 aircraft.

Also in support of the BOMEX Core Experiment during Periods I, II, and III, Air Force WB-47 and WC-130 aircraft of the 53rd Weather Reconnaissance Squadron, and RB-57 aircraft of the 58th Weather Reconnaissance Squadron flew missions to obtain special synoptic data to describe conditions within the BOMEX array. The flights are listed in table 2-8, and tables 2-9, 2-10, and 2-11 list the basic meteorological instrumentation carried aboard these aircraft. The tracks flown are illustrated in <u>BOMEX Field Observations and Basic Data Inventory</u> (in press), issued by the BOMAP Office.

For the Tropical Convection Program during BOMEX Period IV, when the fixed ships formed a staggered array at positions BRAVO, CHARLIE, ECHO, LIMA, and GOLF (see sec. 1.0.0, fig. 1-2), all aircraft were used to acquire data on tropical disturbances, cloud bands, and the Intertropical Convergence Zone (ITCZ). The complex patterns flown during this period are illustrated in <u>BOMEX Field Observations and Basic Data Inventory</u>, cited above.

Table 2-1. Call signs and other identifiers for BOMEX aircraft

Unit name and type of aircraft	Voice call sign	Abbreviated call	Additional designators
	Line Integral Aircraft		
ESSA Research Flight Facility			
DC-6	Research Six ALFA	RFF-6A	39C (CHARLIE)
DC-6	Research Six BRAVO	RFF-6B	40C (CHARLIE)
DC-4	Research Four	RFF-4	82E
U. S. Navy VW-4 Squadron			
WC-121*	Navy Twenty-One ALFA	N21A	VW-4 21A
WC-121*	Navy Twenty-One BRAVO	N21B	VW-4 21B
	Special Synoptic Aircraft		
USAF Air Weather Service			
53rd Weather Reconnaissance Squadron			
WB-47*	Air Force Four Seven ALFA	AF 47A	
WB-47*	Air Force Four Seven BRAVO	AF 47B	
WC-130*	Air Force Three Zero ALFA	AF 30A	
WC-130*	Air Force Three Zero BRAVO	AF 30B	
58th Weather Reconnaissance Squadron			
RB-57*	Air Force Five Seven ALFA	AF 57A	
RB-57*	Air Force Five Seven BRAVO	AF 57B	

*The tail number designation differed due to rotation of these aircraft during BOMEX.

Table 2-2. Fixed reporting points used in BOMEX

Designation of point	Periods I, II, and III May 1 to July 10		Period IV July 11 to 28	
ALFA	16°50'N	59°12'W	17°30'N	59°00'W
BRAVO	17°36'N	54°34'W	17°30'N	54°00'W
CHARLIE	15°00'N	56°30'W	15°00'N	56°30'W
DELTA	12°23'N	58°23'W	13°00'N	59°00'W
ECHO	13°08'N	53°51'W	13°00'N	54°00'W
FOXTROT	07°57'N	57°36'W	09°00'N	59°00'W
GOLF	08°42'N	53°03'W	07°30'N	52°42'W
HOTEL	14°37'N	58°48'W	15°15'N	59°00'W
INDIA	17°13'N	56°53'W	17°30'N	56°30'W
JULIETT	15°22'N	54°12'W	15°15'N	54°00'W
KILO	12°46'N	56°07'W	13°00'N	56°30'W
LIMA	Not used		10°30'N	56°30'W
MIKE	Not used		09°00'N	57°00'W
NOVEMBER	Not used		09°20'N	54°00'W
OSCAR	Not used		11°00'N	59°00'W
PAPA	Not used		11°00'N	54°00'W
XRAY	16°29'N	54°23'W	Not used	
YANKEE	14°15'N	54°01'W	Not used	

Table 2-3. BOMEX line integral aircraft missions

Date	Aircraft and flight patterns				
	Navy WC-121 A	Navy WC-121 B	RFF DC-6 39C	RFF DC-6 40C	RFF DC-4 82E
May					
3	LIN	-	-	-	-
4	-	LIN	-	LID A	LID B
9	Comparison	Comparison	-	Comparison	Comparison
10	-	LIN MOD 1	-	-	-
11	LIN MOD 2	-	-	LID A	LID B
12	LIN MOD 2	-	LID B	LID A	-
25	LIN MOD 2*	LIN MOD 2**	-	-	-
26	LIN MOD 2	-	-	LID A	LID B
27	LIN MOD 2	-	-	LID A	LID B
31	LIN MOD 2	-	-	-	-
June					
1	LIN MOD 2	-	-	LID A	LID B
2	LIN MOD 2	-	-	LID A	LID B
3	LIN MOD 2	-	-	LID A	LID B
7	LID E	LID F	LID C	LID G	LID D
9	LID E	LID F	LID C	LID G	LID D
22	LID E	LID F	LID C	LID G	LID D
23	LIN F	-	LIN C	LIN D	LIN E
25	LIN E	-	LIN C	LIN D	LIN F
29	LID E	LID F	-	LID C	LID D
30	LID E	LID F	LID D	LID C	-

*Aborted prior to H (HOTEL).

**Direct to J (JULIETT) - I, J, H-I, and return.

Table 2-4. RFF airborne instrumentation systems supporting BOMEX

Parameter	Instrument	Range	Error	Aircraft 39C	Aircraft 40C	Aircraft 82E	Remarks
Aircraft position (latitude, longitude)	Doppler navigation systems; GPL Div. General Precision						
(LAT/LONG)	APN-153	90° N/S 180° E/W		X X	X X	X X	Computed post-flight.
	APN-82	90° N/S 180° E/W		X X	X X	X X	Computed with on-board computer.
	OMEGA navigation system; Tracor	90° N/S 180° E/W			X		Experimental.
Ground speed (GS)	APN-153	60-1,000 kt	(0.2%±0.35) kt	X	X	X	PE shown. Scale factor 36° per 100 kt.
	APN-82	70-700 kt	(±2.1 kt) or (±0.3%) GS	X	X	X	PE shown. RFF experience shows that accuracy is approx. 1%. Time constant for system is: 300 Hz sec^{-1}; ~14 kt sec^{-1}.
Drift angle (DA)	APN-153	±40°	±0.17°	X	X	X	Pitch/roll stabilization provided.
	APN-82	±45°	±0.15°	X	X	X	Pitch/roll stabilization provided.

Table 2-4. RFF airborne instrumentation systems supporting BOMEX (continued)

Parameter	Instrument	Range	Error	Aircraft 39C	40C	82E	Remarks
Wind direction (DDD)	APN-153	360°		X	X	X	Computed post-flight.
	APN-82	360°	$\pm[0.4+(150/\mathrm{FFF}]°$	X	X	X	Computed with on-board computer. Response 2.6° $\sec^{-1}$. Time constant: ~35 sec.
Wind speed (FFF)	APN-153			X	X	X	Computed post-flight.
	APN-82	0-240 kt	[$\pm$3 kt for FFF $\leq$ 150 kt] [$\pm$0.02 (FFF) $\geq$150 kt]	X	X	X	Computed with on-board computer.
Distance travel count (DTC)	APN-82	0-999.999 n mi	~1% DTC	X	X		Recycles through "0."
Aircraft pitch/roll angle (θ/ϕ)	APN-81, Gyro C-1160	$\pm$30° (pitch) $\pm$45° (roll)	$\pm$0.1° $\pm$0.1°	X X	X X		36° $\sec^{-1}$. (Removed from digital tape during BOMEX.)
Magnetic heading (MHDG)	N-1 Flux gate system, w/C-2 transmitter	360°	$\pm$0.2°	X	X	X	36° $\sec^{-1}$. Backup systems available on all aircraft.

Table 2-4. RFF airborne instrumentation systems supporting BOMEX (continued)

Parameter	Instrument	Range	Error	Aircraft 39C	40C	82E	Remarks
Magnetic variation (MVAR)	Manual setting	180° E/W		X	X	X	Obtained from published values.
Ambient pressure (APRESS)	Giannini 555T1 pressure transducer	1,050-50 mb	±0.5 mb	X	X	*	*82E employs alternate pitot-static system. 10-mb sec^{-1} response.
Differential pressure (DPRESS)	Giannini 555T2 pressure transducer	0-200 mb	±0.5 mb	X	X	*	*See note above.
Indicated airspeed (IAS)	Giannini 555T2 pressure transducer	50-400 kt	±5 kt	X	X	*	*See note above.
	Kollsman IAS meter	50-400 kt	±5 kt	X	X	X	
True airspeed (TAS)	Kollsman TAS tranducer	50-700 kt	±5 kt	X	X	X	80-kt sec^{-1} response.
Pressure altitude (PA)	Kollsman altimeter	0-50,000 ft	**	X	X	X	**Bench and in-flight checks performed.
	Giannini 555T1 Pressure tranducer	0-50,000 ft	±15-20 ft	X	X	*	*See note above (**).
Radar altitude (RA)	Stewart-Warner APN-159	Classified	±8 ft or 1% RA	X	X	X	Pitch/roll stabilization provided. 500-ft sec^{-1} response.

Table 2-4. RFF airborne instrumentation systems supporting BOMEX (continued)

Parameter	Instrument	Range	Error	Aircraft 39C	40C	82E	Remarks
Ambient (vortex) temperature (TEMP)	Bendix ML-471/ AMQ-8 vortex	-80 to +50°C	±1°C	X	X	X	10-sec response
	RFF modified AMQ-8 thermocouple vortex	0 to 400°K	< 1°C	X	X	X	Developmental. Response < 5 sec.
Sea-surface temperature (SST)	Barnes PRT-5, IR	-40 to +40°C	±0.5°C	X	X	X	50-msec response time.
	Te radiometer	-20 to ±45°C	±0.5°C	X	X	X	2-sec response time.
Total temperature	Rosemount system	-60 to ±40°C	±1°C	X	X		1/e time ~ 20 msec. Developmental; requires TAS corr.
Liquid water content (LWC)	Levine hot-wire	0 to 10 gm m^{-3}	30-50%	X	X		Also provides the volume median drop size. 4-sec response time.
Absolute humidity	IR hygrometer	0 to 20 (plus) gm m^{-3}	5%	X	X	X	0-10 sec for a 90% change
Dew (frost) point temperature (TD)	Cambridge systems hygrometer	-50 to +50°C	within ±2°C of IRH	X	X		~10-sec response time; faster at temperatures >0°C.

Table 2-4. RFF airborne instrumentation systems supporting BOMEX (continued)

Parameter	Instrument	Range	Error	Aircraft 39C	40C	82E	Remarks
Ice detector	Pressure difference cyclic sensor			X	X		
Aitken nuclei count	APCL System			X	X		Operated by APCL.
Vertical acceleration	Statham AJ-43 accelerometer	0 to ± 3 g	~10%	X	X	X	
Refractive index (N)	Microwave refractometer			X			System operated by WPL; used for rapid measurement of water vapor.
Solar radiation	Eppley precision spectral pyranometer	λ:285-2,800 mμ T:-20 to +50°C	*	X	X	X	*Comparison data obtained for each flight. Sensitivity: [5mv cal^{-1} cm^{-2} min^{-1}], with impedance of 300 ohms.
Radar systems	APS-20E 10.4 cm	200 n mi		X	X		PPI.
	WP-101 5.6 cm	150 n mi		X	X		PPI.
	RDR-ID 3.2 cm	20 n mi		X	X		Cross section.
	APS-42A 3.2 cm	200 n mi				X	PPI.
Radiation detection	Air sampler, foil assembly FI-2A w/B 200A CRM, 90-GM tube	0-200,000 counts		X	X	X	Used with 4 1/4-in. paper filters.

Table 2-5. RFF airborne recording systems

Recorder/Display	MFG/Model	Speed	Channels	Aircraft			Remarks
				39C	40C	82E	
Digital (magnetic tape) recorder	ESS GEE, Inc. mod. by RFF	*	7 BCD	X	X		See (1).
Digital (magnetic tape) recorder	Radiation, Inc.	**	7 BCD 20 FM analog			X	See (2).
FM (IRIG) analog recorder	Sangamo series 3560	Var.	14	X			See (3).
Strip-chart recorder (6 and 8 in.)	Honeywell-visicorder	Var.	14 28	X X	X X	X X	See (4).
Strip-chart recorder	Hewlett-Packard	Var.	2	X	X	X	See (5).
Cloud cameras, side-mounted, 35 mm	Automax G-2	1 fr/5 sec	1	X	X		Mounted left/right.
Cloud camera, forward looking, 16 mm	Milliken DBM-5C	1 fr/2 sec	1	X	X		
Photo-panel camera, 35 mm	Automax G-1	1 fr/5 sec	1	X	X	X	
Radar cameras, 35 mm	Fairchild 0-15	Var.	1	X	X	X	All radars.

(1) Records are 150 BCD characters each in length. *Tape moves at 76 cm sec^{-1}. Recording capacity 4,500 BCD characters per second with bit density of 200 bits per inch. Original system modified by RFF.

(2) Records are 150 BCD characters each in length. **Capability of recording 50 complete samples per second. System can also be used to record 20 channels of analog (FM) data.

(3) Used to record individual components of the water vapor flux system.

(4) Light-beam galvanometer type. Used to record, continuously, output of special instruments.

(5) Electrostatic recorder used for IR and solar radiation measurement recording.

Table 2-6. Navy WC-121 aircraft basic observation system

Parameter measured	Sensor or method of recording
Temperature (total)	AMR-42 potentiometer
Temperature (ambient)	DY2861A
Dew point	Cambridge systems 137-C3 dew pointer
Wind direction at flight level	APN-153 Doppler, ASR-41 adapter
Wind speed at flight level	APN-153 Doppler, ASR-41 adpter
Radar altitude	APN-159 potentiometer
Ambient pressure	Rosemount transducer
Cloud cover	Manually recorded
Sea state	Manually recorded
Sea-surface temperature	Barnes PRT-4A
Subsurface seawater temperature	SSQ-36 bathythermograph
Radar precipitation areas (horizontal)	APS-20 CR-1A camera
Radar precipitation areas (vertical)	APS-45 CR-1A camera
Weather	Manually recorded
Icing	Manually recorded
Date	Manually recorded
Time	Clock
Octant of globe	ASN-41 adapter
Lattidue and longitude	ASN-41 adapter
True airspeed	AX-606 TAS computer
True heading	ASN-41 adapter
Ground speed	APN-153 Doppler
Drift angle	APN-153 Doppler
Compass	CGRS

Table 2-7. Navy WC-121 aircraft meteorological instrumentation

System	Description
Data acquisition logging system (DALS)	
Baththermograph system	SSQ-36 BT probe (0.5°F) ARR-58 receivers (± 1°F) XN-1&3 Rustrack recorder (±0.275°C)
Radiosonde system	AMT-6 radiosonde (± 0.2 mb) AMR-3 radiosonde deceptor MA-1 radiosonde dispenser MH-1 radiosonde adapter sleeve
Airborne radiation thermometer system	PRT-4A radiation thermometer (±0.2°C) 680 Mosely strip-chart recorder (±0.55°C)
AMQ-17 aerograph set	AMA-2 indicator recorder Pressure transducer (± 0.2°C) Temperature humidity probe (±0.5°C, ±3%)
Instruments dials at or near Metro panel	
Absolute altitude indicators	SCR-718 radio altimeter (± 50 ft) APN-159 radar altimeter (± 10 ft)
MA-1 Kollsman pressure altimeter AMQ vortex thermometer C-3 Cambridge dew pointer (± 1°C) True heading indicator Ground speed indicator True airspeed indicator True wind speed indicator Drift angle indicator FA-112 barometer (± 0.5 mb) Clock	
Navigation aids	APN-70 Loran APN-153 Doppler ARN-21 TACAN ARN-14 OMNI ASN-41 navigation computer Sextant BDHI

Table 2-8. Special synoptic aircraft missions

Date	WB-47		RB-57		WC-130			
1969	Radar	Air sampling	Photography	Air sampling	Dropsonde (day)	Dropsonde (night)	Air sampling	Comparison flight
<u>May</u>								
1							X	
3	X	X	X	X	X	X	X	
4	X	X	X	X	X	X	X	
5	X	X	X	X	X	X	X	
6	X	X	X	X	X		X	X
7	X	X	X	X			X	
8				X				
9	X	X	X	X			X	
10		X	X	X	X	X	X	
11	X	X	X	X	X	X	X	
12		X	X	X	X	X	X	
13	X	X		X	X		X	
14	X	X	X	X			X	

Table 2-8. Special synoptic aircraft missions (continued)

Date	WB-47		RB-57		WC-130			
1969	Radar	Air sampling	Photography	Air sampling	Dropsonde (day)	Dropsonde (night)	Air sampling	Comparison flight
<u>May</u>								
15				X				
24	X		X	X				
25	X		X		X	X		
26			X		X	X		
27	X		X		X	X		
28	X		X		X			X
29								
30	X		X					
31	X		X	X	X	X		X
<u>June</u>								
1	X		X		X	X		
2	X		X		X	X		
3	X		X		X	X		
4	X		X		X			
5								

Table 2-8. Special synoptic aircraft missions (continued)

Date	WB-47		RB-57		WC-130			
1969	Radar	Air sampling	Photography	Air sampling	Dropsonde (day)	Dropsonde (night)	Air sampling	Comparison flight
June								
6	X		X					
7	X		X		X	X		
8			X		X	X		
9	X		X		X	X		
10			X					
11				X				
21	X	X	X	X		X	X	
22	X	X	X	X	X	X	X	
23	X	X	X	X		X	X	
24	X	X	X	X	X	X	X	
25	X	X	X	X	X	X	X	
26	X	X	X	X	X		X	X
27				X				
28	X	X	X	X	X	X	X	
29	X	X	X	X	X	X	X	
30	X	X	X	X	X	X	X	
July								
1	X	X		X	X	X	X	X
2		X	X	X			X	

Table 2-9. Air Weather Service WB-47 basic meteorological instrumentation

Measurement	Instrument
Precipitation areas	AN/APS-64 search radar
Altitude	AN/APN-42A radar altimeter MA-1 pressure altimeter
Wind speed and direction at flight level	AN/APN-102 Doppler
Temperature (total)	Rosemount probe
D-value	AN/APN-42, MA-1 altimeter
Particulate air sampling	U-1 foil
Cloud cover	Visual observation
Present weather	Visual observation
Past weather	Visual observation
Turbulence	Subjectively manual
Icing	Visual observation

Table 2-10. Air Weather Service WC-130 basic meteorological instrumentation

Measurement	Sensor
Temperature (total)	Rosemount probe
Wind direction	AN/APN-147 (V) Doppler
Wind speed	AN/APN-147 (V) Doppler
Altitude	AN/APN-133A or SCR-718 radio altimeter MA-1 STD AC aneroid
Radar precipitation	AN/APN-59 radar system
Dropsonde temperature pressure humidity	AN/AMT-6 system ML-419/AMT-4 rod thermistor aneroid cell ML-476/AMT carbon strip
Particulate air sampling	U-1 foil

Table 2-11. Air Weather Service RB-57 basic meteorological instrumentation

Measurement	Sensor
Color photographs of cloud cover	F-415P Fairchild camera system
Particulate air sampling	U-1 foil
Temperature	Rosemount probe
Wind direction and speed at flight level	Doppler, APN-102
Altitude	MA-1 pressure altimeter

2.1.0 RFF AIRCRAFT DATA

Because of the importance for the user to fully understand the processing of the data, a detailed description is given here of step-by-step procedures followed in data reduction, from original recording to final archive product.

The original data obtained by the RFF aircraft were recorded at 200 bits per inch (BPI) on magnetic tape in binary coded decimal (BCD) format at the rate of one complete record per second, including all parameters. These BCD records were edited by RFF for long, short, and noise records and for parity and/or illegal characters. The tape was then rewritten minus the unreliable records onto a higher density (556 BPI) IBM-compatible CONVERT Tape.

There are a number of optional programs designed by RFF and the National Hurricane Research Laboratory (NHRL), NOAA, Miami, Fla., which are tailored to perform specific functions, i.e., analysis of calibration patterns for true airspeed and drift angle correction and the application of computed corrections to the original wind data. These optional programs were used by NHRL in processing the CONVERT Tape to generate the NNV Tape, which was revised by the BOMAP Office for the BOMEX Temporary Archive.

<u>Before any attempt is made to use the NNV data, it is recommended that the Flight Folder described in section 2.1.8 be reviewed thoroughly for an understanding of the nature of the mission, or proposed patterns and deviations from them and of the in-flight status of the equipment. Remarks in the Flight Folder pertaining to instruments used in recording data of particular interest to the user may be significant</u>. A convenient published abstract of the Flight Folder information, including a description of RFF participation in BOMEX, instrumentation, types of missions, and abbreviated logs with route maps of each aircraft flight, is contained in "The NOAA Research Flight Facility's Airborne Data Collection Program in Support of the Barbados Oceanographic and Meteorological Experiment," NOAA Technical Report ERL 198-RFF 4, October 1970. A few refinements to the information contained in that report have been incorporated into the BOMEX Temporary Archive.

The BOMAP Office (now Center for Experiment Design and Data Analysis, NOAA, Rockville, Md. 20852; tel: 301-496-8871) is willing to assist in resolving any difficulties encountered by users of the NNV data.

Sections 2.1.1 through 2.1.5 should also be reviewed carefully for an understanding of the methods used in collecting the data and the process through which the NNV product was filtered into final form.

2.1.1 Original Data

The data collected by the RFF aircraft were assigned a flight identification (ID) number for every mission flown. This number is made up of the year, month, and day, and a letter designating a particular aircraft.

The letter "A" was used for the DC-6 39C; "B" for the DC-6 40C; and "E" for the DC-4 82E. An extra digit at the end of the flight ID number indicates the number of missions flown in one day, e.g., flight number 690526B1 means that the DC-6 40C was flown on May 26, 1969.

Of primary interest to the user of BOMEX data are the RFF original flight data recorded on magnetic tape, because it is essentially from these that the data tapes in the BOMEX Temporary Archive were derived. These original data were recorded aboard the aircraft at the rate of one record every second. Each record consists of 150 characters (seven-track BCD) written on magnetic tape at 200 BPI. There are approximately 10 to 12 hours of data, i.e., 36,000 to 44,000 records, per flight. No record counts are available, but each observation is distinguished by time in hours, minutes, and seconds. Most of the parameters contained in each record must be calibrated, based on constants provided by RFF to convert counts to engineering units.

The DC-6 "A" and "B" aircraft use the APN-82 Doppler radar navigation system as the primary source for basic navigational parameters. During BOMEX, an APN-153 Doppler radar navigation system was included and used for the first time on RFF aircraft because of its better response at altitudes below 1,000 ft. Normally, the "A" and "B" aircraft tape records are identical. When the APN-153 was used, the PITCH and ROLL in the tape record were replaced by GS-153 and DA-153. (See table 2-4, sec. 2.0.0, for parameter abbreviations.)

The DC-6 "A" aircraft operated with the APN-153 on all flights, but the "B" aircraft did not use it until late in May 1969. The "E" aircraft used the APN-153 only; it did not use its APN-82 to record data on tape. The "E" tape record did not contain TAS, DDD, FFF, LONG, LAT, and MVAR; all these elements were derived during subsequent data processing (see sec. 2.1.3). PITCH, ROLL, LWC, TR, and TD were also missing and could not be derived. Another parameter unavailable on the DC-4 "E" aircraft data tape is the memory on/off indicator. On the DC-6 aircraft, the APN-82 system goes into a memory mode when the return radar signal is too weak to compute a ground speed or drift angle (usually the result of hitting very smooth sea surfaces or the aircraft being in a tight turn). In such cases, the last reliable DDD and FFF are stored in the memory and are combined with the TAS and MHDG + MVAR for computation of GS and DA. When the memory is on, a switch on the DC-6 "A" and "B" records indicates this. Because the "E" aircraft record has no memory switch, the user must interpret a memory-on situation when GS-153 and DA-153 do not change over a short period of time.

2.1.2 CONVERT Tape and Original Tape Listing

As noted in section 2.1.0, RFF provides a parity error-free copy, called the CONVERT Tape, of the original data tape. On the CONVERT Tape, all records with parity errors, short lengths (records less than 150 characters), or long lengths (records exceeding 150 characters) have been deleted. The CONVERT Tape has the same format as the original tape, except for the inclusion of two new parameters: the actual record count and the original record count. These two counts are used to show when records have been deleted. An error summary sheet is also provided to enable the user to decide for himself

the relative merit of each flight. A CONVERT Tape record is expanded to 162 characters on seven-track BCD at 556 BPI.

The RFF Original Tape Listing is an every 10-sec record printout in engineering units from the CONVERT Tape. It is a valuable asset in preprocessing the data and gives the user a first look at instances where data are erroneous. It also indicates whether the APN is on memory or not.

The parameters recorded on the original magnetic tape aboard the RFF aircraft are in "count" units; for their mnemonics, see table 2-4 in section 2.0.0. RFF provided the National Hurricane Research Laboratory (NHRL) with the conversion constants listed in table 2-12, which were used in the NHRL data processing program (see sec. 2.1.3) to convert the count units to meteorological and engineering units, with the exception of the infrared hygrometer (IRH) and liquid water count values.

For IRH and liquid water, RFF furnished NHRL with calibration curves for the DC-4 aircraft. NHRL obtained equations by the method of least squares to relate the IRH count values to absolute humidity at 1,015 mb for each of the DC-6 aircraft. The equations are listed below.

<u>DC-6 "A" aircraft</u>

$$H = \text{counts}$$

$$\text{IRH for 1015 mb} = .119 \times 10^{1} + H * (-.443 \times 10^{-2} + H * (.374 \times 10^{-4} + H * (-.749 \times 10^{-7} + H * (.792 \times 10^{-10} + H * (-.390 \times 10^{-14} + H * .739)))))$$

<u>DC-6 "B" aircraft</u>

$$H = \text{counts}$$

$$\text{IRH for 1015 mb} = .89 + H * (-.535 \times 10^{-2} + H * (.336 \times 10^{-4} + H * (-.401 \times 10^{7} + H * (.230 \times 10^{-10} + H * -.448 \times 10^{-14}))))$$

Table 2-12. RFF original tape calibration constants

Parameter mnemonics (name)	Aircraft "A"	"B"	"E"	Range of count	Conversion	Units
LAT (latitude)	X	X	•		(COUNT-100000) *0.001	deg
LONG (longitude)	X	X	•		COUNT *0.001	deg
GS-153 (ground speed)	X	X	X		COUNT *0.2778	kt
DA-82 (drift angle)	X	X	•		(COUNT-500) *0.1	deg
DA-153 (drift angle)	X	X	X		(COUNT-500) *0.1	deg
DDD (wind direction	X	X	•		COUNT *0.1	deg
FFF (wind speed)	X	X	•		COUNT *027778	kt
DTC (distance travelled count)	X	X	•		COUNT *0.001	n mi
PITCH (pitch)	X	X	•		(COUNT-500) *0.1	deg
ROLL (roll)	X	X	•		(COUNT-500) *0.1	deg
MHDG (magnetic heading)	X	X	X		COUNT *0.1	deg
MVAR (magnetic variation)	X	X	X	< 1000	-(COUNT)*0.18	deg
				> 1000	(2000-COUNT) *0.18	deg
APRESS (ambient pressure)	X	X	X		(COUNT+1000) *0.05	mb
DPRESS (differential pressure)	X				COUNT *0.01381	mb
		X			COUNT *0.01379	mb
			X		COUNT *0.1376	mb
TAS (true airspeed)	X	X	•		COUNT *0.4	kt
RA (radar altitude)	X	X	X		COUNT	ft
TEMP (vortex temperature)	X	X			(COUNT-1200) *0.05	deg
			X		(800-COUNT) *0.05	deg
TD (CS1 dew point tempt)	X		•	< 1005	(COUNT-1005) *0.05443	deg
				> 1005	(COUNT-1005) *0.0504	deg
		X		< 1010	(COUNT-1010) *0.055	deg
				> 1010	(COUNT-1010) *0.05	deg
TR (Rosemount temperature)	X	X	•		(COUNT*0.05071-60.14) - 0.0001319*TAS^2	deg

X = available • = unavailable * = multiply blank = ignore

DC-4 "E" aircraft

The "E" aircraft conversion of IRH counts to absolute humidity at 1,015 mb was approximated by means of a series of straight line curves:

H = counts

IRH for 1015 mb = .0070*H - .70 $(100 \leq H < 450)$

IRH for 1015 mb = .0084*H -1.33 $(450 \leq H < 700)$

IRH for 1015 mb = .010*H -2.52 $(700 \leq H < 1050)$

IRH for 1015 mb = .0128*H -5.34 $(1050 \leq H < 1350)$

IRH for 1015 mb = .0166*H -10.46 $(1350 \leq H < 1600)$

IRH for 1015 mb = .0280*H -28.70 $(1600 \leq H < 1800)$

IRH for 1015 mb = .0360*H -43.10 $(1800 \leq H < 1950)$

IRH for 1015 mb = .0500*H -70.40 $(1950 \leq H < 2000)$

The absolute humidity was then obtained from the expression

$$\text{AHUM gm/m}^3 = \text{IRH}\left(\frac{1015}{P+20}\right)^{0.18} * \left(\frac{P}{P+20}\right) * \left(\frac{308}{T}\right),$$

where P is ambient pressure and T is ambient air temperature in degrees absolute.

Liquid water counts from the DC-6 "A" and "B" aircraft data record (the DC-4 "E" aircraft has none) were converted into liquid water measured in gm/m^3 by use of the latest set of RFF liquid water conversion graphs. Each graph has two curves, one for a 0-2 range and the other for a 0-6 range. The ranges are determined by the state of the two switches operated aboard the DC-6 aircraft and recorded into the tape record. The curves are essentially straight lines, and the linear equations that yield liquid water are

"A" aircraft

(0-2) range LIQW = -.0120*(LIQcounts-120) + 1.025

(0-6) range LIQW = -.04411(LIQcounts-180) + .75

"B" aircraft

(0-2) range LIQW = -.0105 * (L1Qcounts-164) + .5

(0-6) range LIQW = - 0.01429 * (L1Qcounts-200) * 3

2.1.3 NHRL Processing of RFF Data

The National Hurricane Research Laboratory (NHRL) was assigned the task of processing the RFF BOMEX data for the BOMAP Office. For this task, NHRL modified its NNV computer program (NHRL Aircraft Data Processing Program) - which is normally used in processing data obtained on RFF flights into hurricanes during the summer and fall of each year - to print out and record meaningful data collected in the region of the BOMEX array. The program was entered from a CDC User 200 Terminal in Miami into a CDC 6600 computer in Suitland, Md., via a 201-B data set telephone line.

The CONVERT Tape was used as input to the NNV Program and had to be calibrated as described in section 2.1.2.

The original clock time as recorded on the CONVERT Tape was generally reliable for most flights and was accepted by the NNV Program as the most nearly correct time available. For some flights, the original time was corrected, with the original record count or the distance traveled count (DTC) used as a guide in reconstructing the time. Jumps in time were in most cases the result of deletion of observations by the CONVERT Program, as discussed in section 2.1.2, or of time loss when tape reels were changed in flight. (This usually applies to the DC-4 "E" aircraft data because this aircraft had only one tape drive aboard.) When the original time was corrected, the ground speed (GS) was changed accordingly.

A bad original tape always poses a problem in terms of the proper method to correct it, especially if it happens to contain navigational parameters, i.e., GS-82, GS-153, DA-82, DA-153, MHDG, APRESS, DP, or TEMP (see table 2-12, sec. 2.1.2). Data cards were used in the NNV Program to interpolate, replace, smooth, delete, or add a correction to any parameter as required. For every flight, the APRESS, MHDG, DA-82, DA-153, GS-82, GS-153, TEMP, DPRESS, and IRH were automatically interpolated up to 11 observations for missing data. Data values were interpolated when the absolute first difference between one parameter and the immediately preceding noninterpolated parameter exceeded a predetermined value derived from the NNV Program data card. The MHDG, DA-82, DA-153, GS-82, GS-153, and calculated TAS values were smoothed over 11 observations. Missing data, usually in the form of a series of 9's, that could not be interpolated were not included in the smoothing process. Corrections were applied to TEMP, IRH, pressure altitude, calculated TAS, DA-82, and DA-153. Usually these corrections were constant for the entire flight, but in some cases different corrections were applied intermittently throughout the flight.

The original MVAR, DDD, FFF, LAT, LONG, and TAS data were not used since the aircraft positions were renavigated, and a calculated TAS (CTAS) was derived from the corrected TEMP, DPRESS, and APRESS for the renavigated flight track and wind computations. The pressure altitude (PA) was derived from the corrected APRESS. A PA correction was applied when required, and a new APRESS was then derived. For the DC-6 "A" and "B" aircraft, GS was derived from DTC and the corrected time; for the DC-4 "E" aircraft, GS-153 was taken directly from the CONVERT Tape, since no DTC was available.

GS-153 and DA-153 were used from the "A" and "B" aircraft tape records if, and only if, the APN-82 system was on memory (see sec. 2.1.1). Selection of the APN-82 system in an off-memory condition is based on the reliability of the APN-82 Doppler navigation system, which has been in use for many years. The APN-153 was installed primarily for BOMEX. In processing the data from the DC-4 "E" aircraft, the APN-82 information was not recorded on the original tape, and the GS-153 and DA-153 were used exclusively. For one flight, the NNV Program forced the acceptance of APN-153 information because the APN-82 was malfunctioning. Whether the APN-82 or the APN-153 was accepted for the renavigated flight track data is clearly indicated on the NNV Tape (see fig. 2-1, sec. 2.1.3.2)

Geographical position on the NNV Tape for all BOMEX RFF flights was derived from the fixed point 15°00'N, 56°30'W - position CHARLIE at the center of the BOMEX array. In most cases, radar film and photopanel backup information was not used, because land shown in the photographs was insufficient as a base for navigation correction.

The NNV Program had to be run twice to obtain reliable data on renavigated flight tracks and positions of the aircraft. The first pass was used in processing renavigated latitude and longitude from the corrected original tape parameters. The second pass was necessary in order to apply linear corrections to the processed renavigated latitude and longitude increments to place the aircraft over known positions at times determined from the navigator's log.

2.1.3.1 AUTO Listing and NNV Data Cards

The first part of the flight listing is a printout called the AUTO Listing, which includes all the NNV Data Cards in time-sequence order, interspersed with occasional printed messages from the programs, and a parameter difference printout. When a card shows no time for start of observation, the time indicated is that of the start of the flight. The "manufactured" time is defined as the best corrected time, computed from the data on the CONVERT Tape (Field 25A - 25C in the BCD Tape Record; see sec. 2.1.3.2) and from time correction cards, described below. When the second difference of the manufactured time or the original time obtained from the CONVERT Tape is other than zero, an asterisk is printed with the first difference on the AUTO Listing. Checks are also made for the first difference ORGCOUNT, DPRESS, APRESS, PA, RA, adjusted D-value (RA-PA adjusted to a standard reference level), MHDG, DA, TEMP, and GS in engineering units and IRH count units when the absolute difference is greater than a predetermined value, which is usually entered by

an XXAUT card. The "XX" is the prefix for the variables shown in table 2-13. COMPARE, TIME, and NOTIME cards are used to correct data times when unreliable original times from the CONVERT Tape are encountered.

The FLIGHT card is the beginning NNV data card and contains the flight ID number, the date of the input tape, the number of input tape reels, the beginning time for constructing the manufactured time, the name of the input reels, the name of the output reels, and the last name of the person processing the data. The printed message INPUT TAPE LABEL is the first part of the NNV "output" table label, and is constructed from data obtained from the CONVERT Tape.

The BOMAP card instructs the NNV Program to produce a BOMAP data list with the specified time rate punched on the card.

The LINK card indicates NHRL data list printout; there are three different rates punched on the card for three combinations of this printout.

The AUT and SMT cards tell the NNV Program which elements (see table 2-13) are to be automatically interpolated or smoothed; the range; and the number of observations to be included. If the absolute difference between one parameter and the immediately preceding noninterpolated parameter exceeds the range specified on the AUT card, the element is interpolated up the number of observations indicated on the AUT card.

HUMCAL and LIQCAL cards inform the NNV Program to calibrate the LQW and IRH counts based on the latest RFF calibration information (see sec. 2.1.2).

WTASQ and/or WTAS53 cards are corrections to the TAS and DA-82 or DA-153.

A DELETE card is used for deleting observations on the CONVERT Tape from the beginning of the flight up to the manufactured time specified on the card.

The START card enters an initial latitude and longitude location into the NNV Program that is used to begin the process of renavigating the flight track data.

DBAR cards supply the 90-sec average D-value (RA-PA) curve information for correcting RA when a D-value falls outside a specified area above or below this curve.

The INTERN card corrections are derived from the first-run renavigated latitude and longitude, and the latitudes and longitudes obtained from the navigator's log. The difference between the known position, which is usually taken from the navigator's log, and the renavigated latitude and longitude at specified times is punched into the INTERN card. A later time with the latitude and longitude corrections is also punched into this card, a time correction adjustment linear curve is derived, and subsequent corrections computed from this curve are applied to the renavigated position to give corrected latitude and longitude (see sec. 2.1.3.2).

Table 2-13. Abbreviations of parameters used with AUT, SMT, CQN, or REP cards for NNV Program

Abbreviation	Element	NNV Tape field No.
PR	Pressure	27
PA	Pressure altitude	28
RA	Radar altitude	29
AS	Calculated true airspeed	30
MH	Magnetic heading	31
GS	Ground speed	32
DR	Drift	33
WD	Wind direction	34
WS	Wind speed	35
WU	Wind U component	36
WV	Wind V component	37
LA	Processed (renavigated) latitude	38
LO	Processed (renavigated) longitude	39
TU	Track U component	40
TV	Track V component	41
VT	Vortex temperature	42
HY	Infrared hygrometer	43
DP	Differential pressure	44
PI	Pitch	45
RO	Roll	46
LW	Liquid water	47
MV	Magnetic variation	48
PT	Rosemount temperatue	49
DA	Adjusted D-value	77
G5	APN-153 ground speed	45
D5	APN-153 drift	46

Printed REFERENCE LEVEL messages indicate when the aircraft changes from one National Advisory Committee for Aeronautics (NACA) standard altitude to another NACA standard altitude.

CQN cards are used to add TEMP, PA, and IRH corrections specifically supplied by RFF for the BOMEX data as corrections to the parameters listed in table 2-13.

REP cards indicate replacement of values for the parameters listed in table 2-13. For example,

T1	GSREP	18399999
T2	GSREP	183 1

means replacing the GS values with 183 knots from time T1 until and including time T2.

Time correction cards OCQN and MCQN are used in reconstructing the manufactured time that appears on all printed and tape output.

MISG cards call for suppression of the AUTO Listing for the parameter indicated, i.e., the data in question are known not to exist. The combination of cards

T1	GSREP	MISG99999
T1	GSMISG	1
T2	GSREP	MISG 1
T2	GSMISG	0

informs the NNV Program to set GS to a value of all 9's for printed and tape output, and to suppress the AUTO Listing printout for GS until time T2.

A combination of cards, usually for the DC-4 "E" flights, consisting of

DRREP	MISG99999
GSREP	MISG99999

sets DA and GS from the APN-82 to missing and forces the NNV Program to accept APN-153, DA-153, and GS-153 in processing this flight.

2.1.3.2 NNV BCD Tape Record

NHRL produced two types of NNV output tapes modified for BOMAP. The first is a BCD Tape Record, the second a Binary Tape Record (see sec. 2.1.3.3).

The BCD Tape Record is generally divided into four distinct areas: (1) the original data converted to engineering units with no corrections, (2) the processed or corrected data, (3) the renavigation data, and (4) the corrected navigation data and derived parameter data. An example of this record is shown in figure 2-1.

On the NNV BCD Tape Record, fields 1 to 24 comprise the original data from the CONVERT Tape, calibrated by means of the RFF calibration constants (see sec. 2.1.2). The distance traveled is calibrated to show the distance since the preceding observation. Otherwise, the data in these fields are as follows:

FIELD 25A - 25C, manufactured time. Original time (FIELD 1), or time from time correction cards, or comparison of DTC (FIELD 9), original count (FIELD 2), and original rate (FIELD 4).

FIELD 26, manufactured time rate. Present time minus past time.

FIELD 27, pressure. Original pressure (FIELD 5), and/or pressure or pressure altitude data cards, or pressure altitude (FIELD 28).

FIELD 28, pressure altitude. Original pressure (FIELD 5), and/or data replace or correction cards.

FIELD 29, radar altitude. Original radar altitude (FIELD 6), and/or data cards (in most cases DBAR cards).

FIELD 30, calculated true airspeed. Calculated from the expression FIELD 30 = (((FIELD 42 (VT + 273.16) * 76.5878 ((FIELD 44 (DP)/ FIELD 27 (PR) +1)$^{.285714}$-1)$^{1/2}$), or from the original TAS (FIELD 7). VT, DP, or PR have, of course, been corrected before the above computation is performed.

FIELD 31, magnetic heading. Original heading (FIELD 8) and/or data cards.

FIELD 32, ground speed. DTC (FIELD 9) and manufactured time (FIELD 25A - 25C) for DC-6 "A" and "B" flights and GS-153 original data for DC-4 "E" flight, and/or data cards, or calculated based on previous reliable parameter.

FIELD 33, drift angle. Drift angle 153 (FIELD 10) if DC-6 "A" or "B", and/or data cards. Drift angle 82 from FIELD 10 if DC-4 "E".

FIELD 42, vortex temperature. Original vortex temperature (FIELD 15) and/or data cards.

FIELD 43, infrared hygrometer. Original hygrometer counts (FIELD 16) and RFF calibration curves as explained in section 2.1.2, and/or data cards.

FIELD 44, differential pressure. Original differential pressure (FIELD 17), and/or data cards.

FIELD 45, pitch or GS-153. GS-153 from original tape record if the APN-153 was operating; otherwise derived from pitch (FIELD 18) and/or data cards.

```
**********************************************************************************
*              *** N H R L   NNV   TAPE     ***                                  *
**********************************************************************************
*                                                                                *
*     (AS OF 11/20/70, USED ON THE CDC 6600, IN SUITLAND, MD., WITH BOMAP MODS)  *
*                                                                                *
*     TAPE MODE         = BCD                                                    *
*     TAPE DENSITY      = 556 BPI                                                *
*     TRACKS            = 7 CHANNEL                                              *
*     RECORD SIZE       = 480 CHARACTERS (LOGICAL RECORD SIZE)                   *
*     BLOCK SIZE        = 2400 CHARACTERS OR (480X5) BLOCK (PHYSICAL RECORD SIZE) *
*     REELS             = MULTI OR SINGLE REEL TAPES                             *
*                                                                                *
*     ALL TAPES HAVE A 480 CHARACTER BEGINNING TAPE LABEL, RECORDS, AN EOF MARK, *
*     THEN A SINGLE 480 CHARACTER RECORD END OF REEL OR EOF FENCE, FOLLOWED      *
*     BY A FINAL EOF MARK.                                                       *
*                                                                                *
**********************************************************************************
*          *** NNV TAPE LABEL FORMAT ***                                         *
**********************************************************************************
*                                                                                *
*     1ST RECORD OF TAPE REEL , 480 CHARACTERS                                   *
*                                                                                *
*   1      LABLE IDENTIFIER,≠BTL≠       (  1-  3)    A3   LITERAL                *
*   2      REEL NUMBER OF THIS REEL  ...(  4-  4)    F1.0 1 OR 2                 *
*   3      FLIGHT NUMBER,YYMMDDAN  .....(  5- 12)    A8   LITERAL                *
*   4      RUN DATE OF PROCESSING,YYMMDD( 13- 18)    F6.0 YEAR,MONTH,DAY         *
*   5      TIME OF RUN DATE,HHMM  ......( 19- 22)    F4.0 HOUR,MINUTES           *
*   6      PGM MODIFICATION NO.  .......( 23- 28)    A6   LITERAL                *
*   7      UNUSED  .....................( 29- 30)    2X                          *
*   8      FLIGHT CARD  ................( 31-110)    8A10 BEG DATA CARD          *
*   9      UNUSED  .....................(111-480)    37A10 BLANKS                *
*                                                                                *
**********************************************************************************
```

Figure 2-1. NHRL NNV BCD Tape Record.

```
********************************************************************************
*      NNV TAPE OBSERVATIONAL DATA RECORD FORMAT                               *
********************************************************************************
*                                                                              *
*               *** NOTES ABOUT THE DATA ***                                   *
*                                                                              *
*               ALL DATA IS IN UNSCALED FORM AND SHOULD BE SCALED ACCORDING TO *
*           THE FORTRAN FORMAT USAGE LISTED UNDER COLUMN FMT,I.E. THERE ARE NO *
*            IMBEDDED DECIMAL POINTS IN THE TAPE RECORD DATA.  EXAMPLES        *
*            (B=BLANK)                                                         *
*            FIELD 27 (PRESSURE) =B98763 ON TAPE, MEANS 987.63 MBS USING FORTRAN *
*            SCALE FACTOR F6.2.                                                *
*                                                                              *
*            THE DATA CONTAINED ON THIS TAPE IS CLASSIFIED AS FOLLOWS-         *
*                                                                              *
*      ORG = ORIGINAL, PRC = PROCESSED, NAV = NAVIGATED, COR = WITH CORRECTIONS *
*      FIELD NUMBERS AGREE WITH THE NHRL FINAL TAPE FORMAT SHEET.             *
*                                                                              *
*  FLD   TYPE  ELEMENT                  CHARACTERS   SIGN FMT  UNITS   APN MISSING *
*   1    PRC EDITED RECORD COUNT  ........(  1-  5) +    F5.0 COUNT               *
*   2    ORG RECORD COUNT  ...............(  6- 10) +    F5.0 COUNT               *
*   3A   ORG TIME  .......................( 11- 12) +    F2.0 HOURS               *
*   3B   ORG TIME  .......................( 13- 14) +    F2.0 MINUTES             *
*   3C   ORG TIME  .......................( 15- 17) +    F3.1 SECS                *
*   4    ORG TIME RATE,FROM SWITCHES  ....( 18- 20) +    F3.1 SECS        999     *
*   5    ORG PRESSURE  ...................( 21- 26) +    F6.2 MBS         0       *
*   6    ORG RADAR ALTITUDE  .............( 27- 31) +    F5.0 FEET        0       *
*   7    ORG TRUE AIR SPEED  .............( 32- 35) +    F4.1 KNOTS    82 9999    *
*   8    ORG MAGNETIC HEADING  ...........( 36- 39) +    F4.1 DEGS        9999    *
*   9    ORG DISTANCE INCREMENT  .........( 40- 44) +    F5.4 NMS         99999   *
*  10    ORG DRIFT ANGLE  ................( 45- 48) +,-  F4.1 DEGS        999     *
*  11    ORG WIND DIRECTION  .............( 49- 52) +    F4.1 DEGS     82 9999    *
*  12    ORG WIND SPEED  .................( 53- 56) +    F4.1 KNOTS    82 9999    *
*  13    ORG LATITUDE(+ IF NORTH)  .......( 57- 62) +,-  F6.3 DEGS     82 99999   *
*  14    ORG LONGITUDE(+ IF EAST)  .......( 63- 69) +,-  F7.3 DEGS     82 999999  *
*  15    ORG VORTEX TEMPERATURE  .........( 70- 74) +,-  F5.2 DEGS C.     9999    *
*  16    ORG INFRARED HYGROMETER  ........( 75- 78) +    F4.0 COUNTS      9999    *
*  17    ORG DIFFERENTIAL PRESSURE  ......( 79- 83) +    F5.2 MBS         0       *
*  18    ORG PITCH OR GS(APN-153)  .......( 84- 87) +,-  F4.1 DGS/KTS 153 999     *
*  19    ORG ROLL OR DRIFT(APN-153)  .....( 88- 91) +,-  F4.1 DEGS    153 999     *
*  20    ORG LIQUID WATER  ...............( 92- 95) +    F4.0 COUNTS      9999    *
*  21    ORG MAGNETIC VARIATION  .........( 96-100) +,-  F5.1 DEGS        9999    *
*  22    ORG INDICATORS,3 PER CHAR  ......(101-106) +   6F1.0 BIN CODE            *
*                                                                              *
*    *****************************************************************        *
*    *CHAR ADD 1 IF TRUE         ADD 2 IF TRUE        ADD 4 IF TRUE       *     *
*    * 101 FLIGHT EVENT 1        FLIGHT EVENT 2       FLIGHT EVENT 3      *     *
*    * 102 FLIGHT EVENT 4        FLIGHT EVENT 5       FLIGHT EVENT 6      *     *
*    * 103 NAVIG EVENT 1         NAVIG EVENT 2        RADAR EVENT 1       *     *
*    * 104 VISITOR EVENT 1       VISITOR EVENT 2      DIGITAL EVENT 1     *     *
*    * 105 APN-82 RUN            APN-82 MEMORY        ICE INDICATOR       *     *
*    * 106 HYGROMETER RANGE      NUCLEI COUNTER       HOT WIRE RANGE      *     *
*    *****************************************************************        *
*                                                                              *
*  23A ORG CSI DEW POINT  ...............(107-110) +    F4.0 COUNTS      9999    *
*  23B ORG APN-153 MEMORY(0=ON MEM)  ....(111-111) +    F1.0 COUNT   153          *
*  23C UNUSED  ..........................(112-115)      4X   BLANKS               *
*  24  ORG ROSEMOUNT TEMPERATURE  .......(116-120) +,-  F5.2 DEGS C.     9999    *
```

Figure 2-1. NHRL NNV BCD Tape Record (continued).

```
*  25A PRC MANUFACTURED TIME  ..........(121-122) +   F2.0 HOURS                *
*  25B PRC MANUFACTURED TIME  ..........(123-124) +   F2.0 MINS                 *
*  25C PRC MANUFACTURED TIME  ..........(125-127) +   F3.1 SECS                 *
*  26  PRC MANUFACTURED TIME RATE .....(128-130) +   F3.1 SECS         999     *
*  27  PRC PRESSURE ...................(131-136) +   F6.2 MBS          0       *
*  28  PRC PRESSURE ALTITUDE  ..........(137-141) +   F5.0 FEET         0       *
*  29  PRC RADAR ALTITUDE  .............(142-146) +   F5.0 FEET         0       *
*  30  PRC CALCULATED TRUE AIR SPEED  ..(147-150) +   F4.1 KNOTS        9999    *
*  31  PRC MAGNETIC HEADING  ...........(151-154) +   F4.1 DEGS         9999    *
*  32  PRC GROUND SPEED  ...............(155-158) +   F4.1 KNOTS        9999    *
*  33  PRC DRIFT ANGLE ................(159-162) +,- F4.1 DEGS         999     *
*  34  NAV WIND DIRECTION  .............(163-166) +   F4.1 DEGS         9999    *
*  35  NAV WIND SPEED  .................(167-170) +   F4.1 KNOTS        9999    *
*  36  NAV WIND U-COMPONENT  ...........(171-175) +,- F5.1 KNOTS        9999    *
*  37  NAV WIND V-COMPONENT  ...........(176-180) +,- F5.1 KNOTS        9999    *
*  38  NAV LATITUDE(+ IF NORTH)  .......(181-186) +,- F6.3 DEGS         99999   *
*  39  NAV LONGITUDE(+ IF EAST)  .......(187-193) +,- F7.3 DEGS         999999  *
*  40  NAV TRACK U-COMPONENT  ..........(194-198) +,- F5.1 KNOTS        9999    *
*  41  NAV TRACK V-COMPONENT  ..........(199-203) +,- F5.1 KNOTS        9999    *
*  42  PRC VORTEX TEMPERATURE  .........(204-208) +,- F5.2 DEGS C.      9999    *
*  43  PRC INFRARED HYGROMETER  ........(209-212) +   F4.1 CNTS/GM/M3  9999    *
*  44  PRC DIFFERENTIAL PRESSURE  ......(213-217) +   F5.2 MBS          0       *
*  45  PRC PITCH OR GS(APN-153)  .......(218-221) +,- F4.1 DEG OR KNTS 999     *
*  46  PRC ROLL OR DRIFT(APN-153)  .....(222-225) +,- F4.1 DEGS         999     *
*  47  PRC LIQUID WATER  ...............(226-229) +   F4.1 CNTS/GM/M3  9999    *
*  48  PRC MAGNETIC VARIATION  .........(230-234) +,- F5.1 DEGS                 *
*  49  PRC ROSEMOUNT TEMPERATURE  ......(235-239) +,- F5.2 DEGS C.      9999    *
*  50  NAV INDICATOR=1,IF 153 WNDS USED (240-240) +   F1.0 COUNT                *
*  51-53     UNUSED  ..................(241-257)     17X  GARBAGE              *
*  54  PRC TRUE HEADING  ...............(258-261) +   F4.1 DEGS         9999    *
*  55  PRC TRACK ANGLE  ................(262-265) +   F4.1 DEGS         9999    *
*  56  WND CMP PAR TO TRK(+WITH TRK)  ..(266-271) +,- F6.1 KNOTS    153 9999    *
*  57  WND CMP PRP TO TRK(+L TO R)  ....(272-278) +,- F7.1 KNOTS    153 9999    *
*  58  COR CSI SPECIFIC HUMIDITY  ......(279-282) +   F4.1 GMS/KG       9999    *
*  59  COR SPECIFIC HUMIDITY  ..........(283-286) +   F4.1 GMS/KG       9999    *
*  60-61     UNUSED  ..................(287-296)     10X  GARBAGE              *
*  62  CSI MIXING RATIO  ...............(297-301) +   F5.2 GM/KG        9999    *
*  63-67     UNUSED  ..................(302-324)     23X  GARBAGE              *
*  68  WND CMP PAR TO TRK(+WITH TRK)  ..(325-329) +,- F5.1 KNOTS     82 9999    *
*  69  WND CMP PRP TO TRK(+L TO R)  ....(330-334) +,- F5.1 KNOTS     82 9999    *
*  70  REFERENCE LEVEL HEIGHT  .........(335-339) +   F5.0 FEET         0       *
*  71  REFERENCE LEVEL TEMPERATURE  ....(340-344) +,- F5.2 DEGS C.      9999    *
*  72  LAPSE RATE(PER 1000 FT)  ........(345-350) -   F6.4 DEGS C.      999999  *
*  73  ADJUSTED VORTEX TEMPERATURE  ....(351-355) +,- F5.2 DEGS C.      9999    *
*  74  ADJUSTED ROSEMOUNT TEMPERATURE  .(356-360) +,- F5.2 DEGS C.      9999    *
*  75  POTENTIAL TEMPERATURE  ..........(361-365) +   F5.2 DEGS A.      99999   *
*  76  D-VALUE  ........................(366-371) +,- F6.0 FEET         99999   *
*  77  ADJUSTED D-VALUE  ...............(372-377) +,- F6.0 FEET         99999   *
*  78  DEW POINT TEMPERATURE  ..........(378-382) +,- F5.2 DEGS C.      9999    *
*  79  MIXING RATIO  ...................(383-386) +   F4.2 GM/KG        9999    *
*  80  RELATIVE HUMIDITY  ..............(387-390) +   F4.1 PER CENT     9999    *
*  81  EQUIVALENT POTENTIAL TEMPERATURE (391-395) +   F5.2 DEGS A.      99999   *
*  82  ADJUSTED DEW POINT(CONST MIX RAT)(396-400) +,- F5.2 DEGS C.      9999    *
*  83  COR LATITUDE(+ IF NORTH)  .......(401-406) +,- F6.3 DEGS         99999   *
*  84  COR LONGITUDE(+ IF EAST)  .......(407-413) +,- F7.3 DEGS         999999  *
*  85  COR WIND DIRECTION  .............(414-417) +   F4.1 DEGS         9999    *
*  86  COR WIND SPEED  .................(418-421) +   F4.1 KNOTS        9999    *
*  87  COR WIND U-COMPONENT  ...........(422-426) +,- F5.1 KNOTS        9999    *
*  88  COR WIND V-COMPONENT  ...........(427-431) +,- F5.1 KNOTS        9999    *
*  89  UNUSED  .........................(432-432)     1X   BLANK                *
```

Figure 2-1. NHRL NNV BCD Tape Record (continued)

```
*    ********************************************************************    *
*    *EACH CHARACTER FROM FLD(90-107) ARE LETTER CODE FLAGS WHICH INDICATE*    *
*    *THAT WHICH HAS BEEN DONE TO 18 OF THE BASIC PROCESSED ELEMENTS.     *    *
*    *DESCRIPTION OF THE CODE .                                           *    *
*    *  LETTER   MEANING                                                  *    *
*    *     R   =  A REPLACED VALUE.                                       *    *
*    *     I   =  AN INTERPOLATED OR A SMOOTHED VALUE.                    *    *
*    *     A   =  A SMOOTHED, REPLACED VALUE.                             *    *
*    *     S   =  A SMOOTHED, INTERPOLATED VALUE.                         *    *
*    *     E   =  AN ELEMENT EXCEEDS THE THRESHOLD VALUE.                 *    *
*    *     M   =  A MISSING ELEMENT.                                      *    *
*    *     B   =  A SMOOTHED ELEMENT WHICH EXCEEDS THE THRESHOLD VALUE    *    *
*    *            BEFORE THE ELEMENT WAS SMOOTHED.                        *    *
*    *     P   =  AN ELEMENT THAT HAS EXCEEDED THE STRING COUNT BUT WILL  *    *
*    *            BE CARRIED ON TAPE AS EXCEEDING THE THRESHOLD VALUE.    *    *
*    ********************************************************************    *
*                                                                            *
*  90  FLAG  1-PRC PRESSURE  ...........(433-433)     A1   LETTER CODE       *
*  91  FLAG  2-PRC RADAR ALTITUDE  .....(434-434)     A1   LETTER CODE       *
*  92  FLAG  3-PRC CALC. TRUE AIR SPEED (435-435)     A1   LETTER CODE       *
*  93  FLAG  4-PRC MAGNETIC HEADING  ...(436-436)     A1   LETTER CODE       *
*  94  FLAG  5-PRC GROUND SPEED  .......(437-437)     A1   LETTER CODE       *
*  95  FLAG  6-PRC DRIFT ANGLE  ........(438-438)     A1   LETTER CODE       *
*  96  FLAG  7-NAV WIND DIRECTION  .....(439-439)     A1   LETTER CODE       *
*  97  FLAG  8-NAV WIND SPEED  .........(440-440)     A1   LETTER CODE       *
*  98  FLAG  9-NAV LATITUDE  ...........(441-441)     A1   LETTER CODE       *
*  99  FLAG 10-NAV LONGITUDE ...........(442-442)     A1   LETTER CODE       *
* 100  FLAG 11-PRC VORTEX TEMPERATURE  .(443-443)     A1   LETTER CODE       *
* 101  FLAG 12-PRC HUMIDITY  ...........(444-444)     A1   LETTER CODE       *
* 102  FLAG 13-PRC DIFFERENTIAL PRESSURE(445-445)     A1   LETTER CODE       *
* 103  FLAG 14-PRC PITCH  ..............(446-446)     A1   LETTER CODE       *
* 104  FLAG 15-PRC ROLL  ...............(447-447)     A1   LETTER CODE       *
* 105  FLAG 16-PRC LIQUID WATER  .......(448-448)     A1   LETTER CODE       *
* 106  FLAG 17-PRC ROSEMOUNT TEMPERATURE(449-449)     A1   LETTER CODE       *
* 107  FLAG 18-D-VALUE  ................(450-450)     A1   LETTER CODE       *
* 108  PRC CSI(CALIB)  .................(451-455) +,-  F5.2 CALIB             *
* 109  ORG OMEGA  ......................(456-460) +    F5.0 COUNTS            *
* 110  UNUSED  .........................(461-463)      3X   GARBAGE           *
* 111  PRC WIND DIRECTION(APN-153)  ....(464-467) +    F4.1 DEGS   153 9999   *
* 112  PRC WIND SPEED(APN-153)  ........(468-471) +    F4.1 KNOTS  153 9999   *
* 113  UNUSED  .........................(472-480)      9X   BLANKS            *
*                                                                            *
******************************************************************************
```

Figure 2-1. NHRL NNV BCD Tape Record (continued).

```
*************************************************************************************
*              *** END OF FILE OR REEL RECORD ***                                   *
*************************************************************************************
*                                                                                   *
*     A SINGLE 480 CHARACTER RECORD WITH A LITERAL EOF OR EOR TO DETERMINE THE      *
*     ACTUAL END OF A SINGLE OR MULTI-REEL FILE                                     *
*                                                                                   *
*     IF END OF REEL WITH ANOTHER REEL TO FOLLOW.                                   *
*  1   LITERAL = EOR  ..................(  1-  3)     A3   EOR                      *
*  2   UNUSED  .........................(  4-480)     477X BLANKS                   *
*     IF END OF FILE WITH NO REELS TO FOLLOW.                                       *
*  1   LITERAL = EOF  ..................(  1-  3)     A3   EOF                      *
*  2   UNUSED  .........................(  4-480)     477X BLANKS                   *
*************************************************************************************
```

Figure 2-1. NHRL NNV BCD Tape Record (continued).

FIELD 46, roll or DA-153. DA-153 from original tape record if the APN-153 was operating; otherwise derived from roll (FIELD 19), and/or data cards.

FIELD 47, liquid water. Original liquid water counts (FIELD 20) and RFF calibration information (see sec. 2.1.2), and/or data cards.

FIELD 48, magnetic variation. Derived from the NNV Program after processing of latitude and longitude.

FIELD 49, Rosemount temperature. Original Rosemount temperature (FIELD 24), and/or data cards.

FIELD 54, true heading. FIELD 31 (MHDG) + FIELD 48 (MVAR).

FIELD 55, track angle. FIELD 54 (THDG) + ((FIELD 33 (DA) or FIELD 46 (DA-153)).

<u>Renavigated data consist of the following:</u>

FIELD 34, wind direction. 270 - arctan (FIELD 37 (WV)/FIELD 36 (WU)).

FIELD 35, wind speed. (FIELD 36 $(WU)^2$ + (FIELD $(WV)^2)^{1/2}$.

FIELD 36, wind U-component. FIELD 40 (TU) - sin (FIELD 30 (CTAS)), or data cards.

FIELD 37, wind V-component. FIELD 41 (TV) - cos (FIELD 30 (CTAS)), or data cards.

FIELD 38, processed latitude. Present FIELD 38 = past FIELD 38 + (FIELD 41 (TV) * FIELD 26 (RATE))/36000.

FIELD 39, processed longitude. Present FIELD 39 = past FIELD 39 - (FIELD 40 (TU) * FIELD 26 (RATE))/36000 * cos (FIELD 38 (PLAT)/34377.5).

FIELD 40, track U-component.

(a) When APN-82 is used,
FIELD 32 (GS) * (sin (FIELD 30 (CTAS)) * cos (FIELD 33 (DA)) + cos (FIELD 30 (CTAS)) * sin (FIELD 33 (DA)).

(b) When APN-153 is used,
FIELD 45 (GS-153) * (sin (FIELD 30 (CTAS)) * cos (FIELD 46 (DA-153)) + cos (FIELD 30 (CTAS)) * sin (FIELD 46 (DA-153)).

(c) When a wind direction and wind speed are entered by data card or the WU component (FIELD 26) is held constant for a short time, TU is derived from sin (FIELD 30 (CTAS)) + FIELD 36 (WU).

FIELD 41, track V-component.

(a) When APN-82 is used,
FIELD 32 (GS) * (cos (FIELD 30 (CTAS)) * sin (FIELD 33 (DA)) - sin (FIELD 30 (CTAS)) * cos (FIELD 33 (DA))).

(b) When APN-153 is used,
FIELD 45 (GS-153) * (cos (FIELD 30 (CTAS)) * sin (FIELD 46 (DA-153)) - sin (FIELD 30 (CTAS)) * cos (FIELD 46 (DA-153))).

(c) When a wind direction and wind speed are entered by data card or the WV component (FIELD 37) is held constant for a short time, TV is derived from cos (CTAS) + FIELD 37 (WV).

Corrected parameters are derived as follows:

FIELD 83, corrected latitude. FIELD 38 (PLAT) + correction from INTERN card correction curve.

FIELD 84, corrected longitude. FIELD 39 (PLONG) + correction from INTERN card correction curve.

FIELD 85, corrected wind direction. Modular 360 (270 - arctan (FIELD 88 (CWV)/FIELD 87 (CWU)).

FIELD 86, corrected wind speed. (FIELD 87 $(CWU)^2$ + FIELD 88 $(CWV)^2)^{1/2}$.

FIELD 87, corrected wind U-component. Same as FIELD 36 (WU), unless corrections are applied.

FIELD 88, corrected wind V-component. Same as FIELD 37 (WV), unless corrections are applied.

Some final derived parameters are:

FIELD 56, parallel component of wind to BOMEX array (APN-153). From sin (FIELD 55 (TRK)) * WU component for APN-153 winds + cos (FIELD 55 (TRK)) * WV component for APN-153 winds.

FIELD 57, perpendicular component of wind to BOMEX array (APN-153). From cos (FIELD 55 (TRK)) * WV component for APN-153 winds - sin (FIELD 55 (TRK)) * WU component for APN-153 winds.

FIELD 68, parallel component of wind to BOMEX array (APN-82). From sin (FIELD 55 (TRK)) * WU component for APN-82 winds + cos (FIELD 55 (TRK)) * WV component for APN-82 winds.

FIELD 69, perpendicular component of wind to BOMEX array (APN-82). From cos (FIELD 55 (TRK)) * WV component for APN-82 winds - sin (FIELD 55 (TRK)) * WU component for APN-82 winds.

FIELD 58, corrected CSI specific humidity. FIELD 62 (CSI, MIXRATIO)/(1000 + FIELD 62) * 100.

FIELD 59, corrected specific humidity. FIELD 79 (MIXRATIO)/(1000 + FIELD 79) * 100.

The following mixing ratio parameters were computed based on the article "An Approximation Formula to Compute Relative Humidity From Dry Bulb and Dew Point Temperature," by Julius F. Bosen, Monthly Weather Review, December 1968.

If we let

TEMP = FIELD 42 (VT),

ABVT = FIELD 42 (VT) + 273.16°,

OCSI = FIELD 23A (CSI counts),

PRESS = FIELD 27 (pressure in mb), and

HYGR = FIELD 43 (absolute humidity in gm/m),

then we can derive dew point (FIELD 78), relative humidity (FIELD 80), and mixing ratio (FIELD 79) from

$$E = 461.5 \times 10^{-6} * \text{HYGR} * \text{ABVT}, \text{ and}$$

$$ES = 10^{(22.5518 - (2937.4/\text{ABVT}) - 4.9283 * \text{Alog}(\text{ABVT}))},$$

giving

FIELD 78, dew point = (E/ES),

FIELD 80, relative humidity = 100 * E/ES, and

FIELD 79, mixing ratio = (62200 * E)/((0.1 * PRESS) - E).

FIELD 62, CSI mixing ratio, is derived from

$$ESI = ((\text{OCS1} + 112.111 - .1 * \text{TEMP})/(112.111 + 9 * * \text{TEMP})^{(1/125)} * ES,$$

from which

FIELD 62 = (62200 * ES1)/((.1 * PRESS) - ES1) is obtained.

FIELD 70, reference level height. Determined by RA (FIELD 29).

FIELD 71, reference level temperature. Determined by RA (FIELD 29).

FIELD 72, lapse rate. Minus 1.7°C/1,000 ft for all flights.

FIELD 73, adjusted vortex temperature. FIELD 42 (VT) - FIELD 72 (lapse) * (FIELD 28 (PA) - FIELD 70 (RHT)).

FIELD 74, adjusted Rosemount temperature. FIELD 49 (ROSE) + ((FIELD 42 (VT) - FIELD 73 (AVT)).

FIELD 75, potential temperature. (FIELD 42 (VT) + 273.16 * (1/FIELD 29 (PRESS))$^{.28674}$.

FIELD 76, D-value. FIELD 29 (RA) - FIELD 28 (PA).

FIELD 77, adjusted D-value. If we let

RA = FIELD 29,

PA = FIELD 28,

RH = FIELD 70,

VT = FIELD 42,

AVT = VT + 273.16,

RT = FIELD 71, and

LAPSE = FIELD 72,

then the adjusted D-value = RA - PA - (PA - RH) * ((VT + ((RH - PA)/2) * LAPSE) - RT)/PA.

FIELD 82, adjusted dew point. FIELD 78 (DEWP) + (FIELD 73 (AVT) - FIELD 42 (VT)).

2.1.3.3 NNV Binary Tape Record

As stated in the preceding section, the second tape produced by NHRL and modified for BOMAP is the NNV Binary Tape Record. Most of the elements on this tape come directly from the NNV BCD Tape discussed in the preceding section, with feet converted to meters and knots converted to meters per second. The format for the NNV Binary Tape is given in table 2-14; the logical record is described in table 2-15.

NOTE: A conversion error was made on the NNV Binary Tape. Multiply RA, PA, and D-value by 0.9232.

The following parameters produced by the NNV Program not recorded on the NNV BCD Tape Record were derived for and written on the NNV-BOMAP Binary Tape:

For WORDS 34-37, the U and V wind components were generally derived in the same way as FIELDS 36 and 37 on the BCD record (see preceding section). When the APN-82 is used, the U and V components are derived from GS and DA. When the APN-153 is used, these components are derived from GS-153 and DA-153.

WORD 40 by the letters "A," "B," "C," and "D," or a blank, indicates the "corridor" in which the aircraft was flying. These corridors consisted of paths 60 n mi long along each of the four sides of the BOMEX array. The southern corridor was designated "A," the eastern "B," the northern "C," and the western "D." When the aircraft was flying in one of these corridors, the TRACK ANGLE (FIELD 55) on the NNV BCD Tape (see preceding section) is the angle formed between any two adjacent corners of the BOMEX array with reference to north. This constant TRACK ANGLE is used in deriving the information in WORDS 26-29. A blank for WORD 40 indicates that the aircraft was not flying in a corridor.

WORDS 41-42 are the corrections applied to CTAS and DA-153 based on the WTASQ card described in section 2.1.3.1.

WORDS 43-44 are the corrections applied to CTAS and DA-153 based on the WTAS53 card, also described in section 2.1.3.1.

Table 2-14. NHRL NNV-BOMAP Binary Tape Record format

Characteristic	Description
Tape mode	Binary, floating point, written by a 60-bit register from the CDC 6600
Tape density	800 BPI
Tracks	Seven
Record size (logical)	440 characters (44 x 10)
Block size (physical)	14,400 characters (440 x 60)
Word size	10 characters
Reels	Always single

NOTE: The first record of the tape is a tape label with the following information in the first 10 words:

WORD (1,1) = 'BOMAP 'literal

WORD (2,1) = BCD date

WORD (3,1) - WORD (10,1) = FLIGHT card information (see sec. 2.1.3.1)

In the last record, WORD (1,1) = -1. is followed by an end-of-file mark.

Table 2-15. Logical record of NHRL NNV-BOMAP Binary Tape

Word	Contents	Units	Field No. from NNV BCD Tape
1	Manufactured time	sec	25A-25C
2	Aircraft corrected latitude	deg	83
3	Aircraft corrected longitude	deg	84
4	True heading	deg	54
5	Radar altitude	m	29
6	Pressure altitude	m	28
7	D-value	m	29,28
8	Pressure	mb	27
9	Vortex temperature	°C	42
10	Primary (Rosemount) temperature	°C	49
11	Potential temperature	°K	75
12	Specific humidity	gm/kg	59
13	Dew point	°C	58
14	Relative humidity	%	80
15	Liquid water	gm/m^3	47
16	Calculated true airspeed	mps	30
17	Ground speed (APN-82)	mps	32
18	Drift (APN-82)	deg	33
19	APN-82 memory switch indicator (1=off memory, 3=on memory)	count	22
20	Ground speed (APN-153)	mps	45
21	Drift (APN-153)	deg	33
22	APN-153 memory switch indicator (0=on memory, 1=off memory)	count	23B
23	WU component of APN winds (APN-82 or APN-153)	mps	87

Table 2-15. Logical record of NHRL NNV-BOMAP Binary Tape (continued)

Word	Contents	Units	Field No. from NNV BCD Tape
24	WV component of APN winds (APN-82 or APN-153)	mps	88
25	Indicator of winds used for renavigation (0=APN-82) (1=APN-153)	count	--
26	APN-82 parrallel component to BOMEX array	m	68
27	APN-82 perpendicular component to BOMEX array	m	69
28	APN-153 parallel component to BOMEX array	m	56
29	APN-153 perpendicular component to BOMEX array	m	57
30	Corrected wind direction APN-82	deg	85
31	Corrected wind speed APN-82	mps	86
32	Corrected wind direction APN-153	deg	111
33	Corrected wind speed APN-153	mps	112
34	WU component for APN-82 winds	mps	--
35	WV component for APN-82 winds	mps	--
36	WU component for APN-153 winds	mps	--
37	WV component for APN-153 winds	mps	--
38	Absolute humidity	gm/m^3	43
39	CSI original data	count	23A
40	Letter indicator for the BOMEX array corridors ("A", "B", "C", or "D")	literal	--
41	True airspeed correction for APN-82	mps	--
42	Drfit correction for APN-82	deg	--
43	True airspeed correction for APN-153	mps	--
44	Drift correction for APN-153	deg	--

2.1.6 RFF Aircraft Data Archive Magnetic Tape Format

The RFF tapes are written in binary coded decimal (BCD) format at 800 bits per inch. Most tapes contain data for two flights, one flight per file. The two files are separated by four physical end-of-file marks and another four follow the second file. A few tapes contain data for only one flight.

The first record in each file is a header record (see fig. 2-2) of 1,440 alpha numeric characters that describe the data records. The second and subsequent records are data records, each of which contains data for 20 observations taken at 1-sec intervals. Each observation consists of 43 elements in the format shown in table 2-16. Missing data may be recorded as 99, 999, 9999, 99999, *9, *99, *999, or *9999.

Note that the header record format specifications, as comparison between figure 2-2 and table 2-16 shows, are incorrect for several elements. Note also that because the archived tapes were prepared from data on the NNV Binary Tape, there is an error in elements 5 and 6 (radar altitude and pressure altitude). As indicated in section 2.1.3.3, to correct this error, multiply the value on the tape by 0.9232.

Characteristics of the RFF Aircraft Data To Be Considered Before Use in Analysis.

The following notes were made by personnel of the National Hurricane Research Laboratory (NHRL) while reviewing the processed RFF renavigated flight track data. Note that when either the APN-153 or APN-82 Doppler navigation system was on memory, the equipment was operating improperly due to either altitude limits of the Doppler, flight characteristics of the aircraft, or state of the sea surface. The winds derived from such data are therefore suspect. The reference below to navigation error is defined as the error in a manually derived correction to the Doppler navigated track from independent navigation fixes reported by the RFF flight crew. (Sources of these fixes were Omega, fixed-ship positions on station, known position from radar targets, etc.). These errors were found on recomputation of the navigation correction by NHRL personnel. These notes and others are listed below in chronological order and are by no means complete for any one mission, nor do they cover all missions. The comments should be interpreted as typical characteristics to be expected in the data and should be evaluated by the user before analysis.

690504B. A few winds from the APN-153 at 114230 GMT (hrs, min, sec) appear suspect. A navigation error of 10 n mi at longitude 59°39'W while all other corrections are within 1.8 n mi.

690504E. Navigation is good. WNW wind of over 5 mps found from 1708 to 1758 and 1952 to 2050. A 1-sec observation missing from tape every 20 to 30 sec.

690505A1. Navigation error within ± 2 n mi. APN-153 and APN-82 on memory most of the time.

```
 01/30/71 COPY OF RFF FLIGHT DATA (THE BOMAP BINARY OUTPUT TAPE) REEL B2013P
FORMAT OF TAPE IS 1 HEADER RECORD (BCD  1380 CHAR.), 1 EOF, DATA RECORDS(BCD 360
0  CHAR.), AND  4 EOFS. PHYSICAL DATA  CONTAIN  20 1 SECOND OBS. OF 43 VARIABLES
EACH SECOND HAS 180 CHARACTERS,WITH THE FOLLOWING FORMAT.
 1-TIME        F5.1 12-Q (CSI)      F3.1 23-V(52)       F5.1 34-V(82)        F5.1
 2-LAT         F4.1 13-RH           F4.1 24-SW(82-53)  F1.0 35-U(153)       F5.1
 3-LONG        F5.1 14-LIQ. WATER   F4.1 25-WPAR(82)   F5.1 36-V(153)       F5.1
 4-HEADING     F5.1 15-TRUE AIR SPD F4.1 26-WPERP(82)  F5.1
 5-RADAR ALT   F5.1 16-GS(APN82)    F4.1 27-WPAR(53)   F5.1 37-ABS Q(IRH)   F4.2
 6-PRESS ALT   F5.1 17-DA(APN82)    F4.1 28-WPER(53)   F5.1 38-DEW PT(CSI)  F5.1
 7-PRESSURE    F5.1 18-SW(APN82)    F1.0 29-DD(82)     F4.1 79-CORR IND     A3
 8-VORTEX TMP  F5.1 19-GS(153)      F4.1 30-FF(82)     F4.1 40-TAS CQN(82)  F4.1
 9-ROSEM  TMP  F5.1 20-OA(153)      F4.1 31-DD(153)    F4.1 41-DA (82)      F4.1
10-POT    TMP  F5.1 21-SW(153)      F1.0 32-FF(153)    F4.1 42-TAS CQN(153) F4.1
11-Q (IRH)     F3.1 22-U(52)        F5.1 33-U(82)      F5.1 43-DA (153)     F4.1
B2053P   B2832N                                                        BOMAP
 09/05/70 FLIGHT690630A16906302140115lB1113B1114B2013B2011B2012B2015 RUTKOWSKI
```

Figure 2-2. Header information that precedes each RFF mission.

Table 2-16. Variables in data record

No.	Variable	Format	Field positions
1	Time into the day from 00 GMT, sec	F5.0	1 - 5
2	Corrected latitude	F4.2	6 - 9
3	Corrected longitude	F5.2	10 - 14
4	Heading, degrees true	F5.2	15 - 19
5	Radar altitude, whole meters	F5.0	20 - 24
6	Pressure altitude, whole meters	F5.0	25 - 29
7	Pressure altitude, mb and tenths	F5.1	30 - 34
8	Vortex temperature, °C	F5.1	35 - 39
9	Rosemount temperature, °C	F5.2	40 - 44
10	Potential temperature, °K	F5.2	45 - 49
11	Specific humidity (IRH), gm/kg	F3.1	50 - 52
12	Specific humdiity (CSI), gm/kg	F3.1	53 - 55
13	Relative humidity, %	F4.1	56 - 59
14	Liquid water, counts	F4.1	60 - 63
15	True airspeed, m/sec	F4.1	64 - 67
16	Ground speed (APN-82), m/sec	F4.1	68 - 71
17	Drift angle (APN-82), deg	F4.1	72 - 75
18	Memory switch (APN-82), 1 - operating 0 - on memory	I1	76
19	Ground speed (APN-153), mps	F4.1	77 - 80
20	Drift angle (APN-153), deg	F4.1	81 - 84
21	Memory switch (APN-153), 1 - operating 0 - on memory	I1	85

Table 2-16. Variables in data record (continued)

No.	Variable	Format	Field positions
22	U wind component (APN-82 or APN-153), mps	F5.1	86 - 90
23	V wind component (APN-82 or APN-153), mps	F5.1	91 - 95
24	Indicator for U and V components (0 = APN-82, 1 = APN-153), mps	I1	96
25	Wind parallel (APN-82), mps	F5.1	97 - 101
26	Wind perpendicular (APN-82), mps	F5.1	102 - 106
27	Wind parallel (APN-153), mps	F5.1	107 - 111
28	Wind perpendicular (APN-153), mps	F5.1	112 - 116
29	Wind direction (APN-82), deg	F4.1	117 - 120
30	Wind speed (APN-82), mps	F4.1	121 - 124
31	Wind direction (APN-153), deg	F4.1	125 - 128
32	Wind speed (APN-153), mps	F4.1	129 - 132
33	U wind component (APN-82), mps	F5.1	133 - 137
34	V wind component (APN-82), mps	F5.1	138 - 142
35	U wind component (APN-153), mps	F5.1	143 - 147
36	V wind component (APN-153), mps	F5.1	148 - 152
37	Absolute humidity (IRH)	F4.2	153 - 156
38	Dew point (CSI)	F5.2	157 - 161
39	Corridor indicator	A3	162 - 164
40	True airspeed correction (APN-82)	F4.1	165 - 168
41	Drift angle correction (APN-82)	F4.1	169 - 172
42	True airspeed correction (APN-153)	F4.1	173 - 176
43	Drift angle correction (APN-153)	F4.1	177 - 180

690509B1. Navigation error within $\pm$ 0.1 n mi. APN-82 short period on memory around 1800.

690509E1. Navigation error within $\pm$ 1.0 n mi. Short period on memory between 1530 and 1533 and at end of flight. Occasional bad radar altitude and D-values.

690510A1. Navigation error within $\pm$ 3.2 n mi. Considerable APN-82 memory conditions and occasional APN-153 memory conditions.

690511A. Navigation error within $\pm$ 2.0 n mi. APN-82 on memory from 1161 to 1945 and APN-153 on memory short periods of time.

690511B. Eight navigation errors within $\pm$ 2.0 to $\pm$ 4.0 n mi, with maximum differences of 5.6 n mi. Period of Doppler memory between 1234 and 1332.

690511E. Navigation errors within $\pm$ 1 n mi. Data missing from 1319 to 1335. Last navigation fix before missing data at 1236.

690512A. Navigation error of $\pm$ 9.6 n mi at 171030. APN-82 on memory during short periods of time during flight. APN-153 on memory near the end of the flight.

690512B. Navigation error of $\pm$ 6.2 n mi in latitude and $\pm$ 8.6 n mi in longitude at 184340. Short periods of memory throughout the flight.

690514A. Navigation error of $\pm$ 12.8 n mi in longitude at 140820. APN-82 on memory from 1247 to 1320, 1501 to 1533, 1629 to 1645, and 1725 to 1742.

690517A. Navigation error within $\pm$ 1.0 n mi except for longitude error of $\pm$ 2.7 n mi at 172254. APN-82 on memory from 1631 to 1654 and 1740 to 1803.

690522A. Navigation error within $\pm$ 1.0 n mi. APN-82 on memory from 2236 to 2248.

690524A. Navigation error within $\pm$ 1.6 n mi. Data on tape ends at 012330, but navigation log indicates flight over at 014707. APN-82 on memory from 1942 to 2105, 2159 to 2246, and 2346 to 0059, in addition to other short periods during flight. APN-153 on memory from 2007 to 2014, 2038 to 2046, and 2048 to 2056.

690526B. Navigation error within $\pm$ 1.0 n mi except for $\pm$ 6.2-n-mi difference at 121834. APN-153 on memory short periods of time during flight. APN-153 no good until 140340.

690526E. Navigation error within $\pm$ 1.0 n mi. Occasional memory conditions on Dopplers. Pressure altitude shows erroneous values occasionally.

690527A. Navigation good. APN-82 on memory from 1341 to 1430, 1515 to 1533, 1600 to 1628, 1726 to 1804, 2019 to 2101, and 2127 to 2131.

690527B. Navigation within ± 1.0 n mi except for an error of ± 2.0 n mi at 201515. APN-82 on memory for short periods of time.

690527E. All navigation errors within ± 1.5 n mi. No APN-153 winds after 1752.

690529A. Pressure malfunctioned throughout flight. Pressure shows a constant value of 908.5 mb throughout flight.

690601A1. Navigation error within ± 1.5 n mi. APN-82 on memory from 1338 to 1500 and APN-153 from 1444 to 1452 and other shorter periods.

690601A2. Navigation error within ± 1.0 n mi. APN-82 on memory from 1805 to 1905, 2001 to 2106, and other short periods. APN-153 on memory from 1827 to 1833, 1852 to 1904, 2023 to 2034, and 2057 to 2104.

690601B. Navigation error within ± 1.0 n mi. APN-82 on memory from 1506 to 1510, 1618 to 1630, 1638 to 1648, 1813 to 1824, and 1850 to 1855. APN-153 shows no memory.

690601E. Navigation error within ± 1.0 n mi. Occasional instances of Doppler memory.

690602E. Navigation error within ± 1.0 n mi. Occasional Doppler memory periods.

690603A. Navigation error within ± 1.8 n mi. APN-153 shows few memory conditions, but APN-82 on memory from 1340 to 1356, 1411 to 1430, 1503 to 1520, 1555 to 1619, 1635 to 1652, 1720 to 1818, and 1845 to 1902.

690603E. Navigation error within ± 1.6 n mi. Occasional Doppler memory condition.

690607A. Navigation error within ± 10.0 n mi. Sporadic Doppler memory conditions throughout flight.

690607B. Navigation error within ± 1.5 n mi, except at 194610, with a latitude error of ± 18.2 n mi and a longitude error of ± 41.0 n mi. APN-82 on memory for short periods of time; APN-153 on memory from 1124 to 1134, 1317 to 1337, 1346 to 1415, and 1429 to 1437. A W to NW wind at beginning of flight.

690609A. No winds or navigation after 1400. Flight began at 1007 and ended at 2153. Pressure maintained a constant value throughout flight.

690609B. Navigation error within ± 2 n mi except for a ± 10.6-n-mi longitude error at 203730. Few short periods of Doppler memory.

690609E. Navigation error within ± 1 n mi except for ± 9.8-n-mi longitude error on last position of flight.

690621A. Navigation error within ± 1 n mi. APN-153 on memory only occasionally; APN-82 on memory from 1904 to 2004 and 2012 to 2106.

690622A. Navigation error less than ± 1 n mi except for ± 9.8-n-mi error at 1412. APN-153 on memory only occasionally, but APN-82 on memory from 1142 to 1223, 1409 to 1428, and 2025 to 2116.

690622B. Navigation error within ± 2.2 n mi, with an error of ± 5.2 n mi at 183850. Few Doppler memory conditions.

690622E. Navigation error within ± 1.0 n mi. Very few Doppler memory conditions.

690623A. Navigation error within ± 1.0 n mi. APN-153 on memory very few times, but APN-82 on memory from 2324 to 0010.

690623E. Navigation error within ± 2.0 n mi with ± 3.8-n-mi error at 002246.

690625B. Navigation error within ± 1.0 n mi. Very few Doppler memory conditions.

690625E. Navigation error within ± 1.0 n mi. From 2353 to 0001, winds appear to be above average velocity from the north. Few Doppler memory conditions.

690628A. Navigation error within ± 1.0 n mi. APN-82 winds appear bad from 1529 to 1825, but Doppler not on memory.

690628E. Navigation error within ± 1.0 n mi. Data on tape end at 201330, while flight ended at 2026. Time jump from 180820 to 183431 due to in-flight tape change.

690629A. APN-82 and APN-153 equipment malfunctioned throughout flight. No navigation data or winds available. Pressure at constant value throughout flight.

690629B. Last longitude in error by ± 4.0 n mi. Time 1330 should read 1230.

690629E. Navigation error within ± 1.0 n mi except for longitude error of ± 9.6 n mi at 1650. No periods of Doppler memory.

690630A. Navigation error within ± 2.0 n mi except for ± 9.4-n-mi error in latitude and ± 10.0-n-mi error in longitude at 2140. APN-82 on memory from 1457 to 1508, 2058 to 2133, and other short periods.

690630B. Navigation error within ± 1.6 n mi. A few short periods of Doppler memory conditions.

690702A. Navigation error within ± 1.0 n mi with a ± 3.2-n-mi error in longitude at 200930. APN-82 Doppler memory conditions from 1504 to 1623, 1639 to 1643, 1651 to 1721, and other shorter periods.

690713A. Navigation error within ± 1.0 n mi. APN-82 memory conditions from 1541 to 1619, 1712 to 1726, and 1802 to 1811. APN-153 memory conditions from 1700 to 1711, 1742 to 1754, 1854 to 1805, and 1938 to 2011. Bad winds from APN-82 from 2042 to 2114.

690713B. Navigation error within ± 1.0 n mi. APN-82 on memory from 1338 to 1437, 1508 to 1512, 1525 to 1532, 1652 to 1646, and 1659 to 1710. APN-153 on memory from 1659 to 1713, 1744 to 1818, 1854 to 1906, 1930 to 2011, and other shorter periods.

690713E. Navigation error within ± 1.0 n mi. All equipment shut down at 1551.

690714A. Navigation error within ± 1.0 n mi.

690714B. Navigation error within ± 2.0 n mi. APN-153 on memory from 1439 to 1448, 1510 to 1525, and 1851 to 1900. APN-82 winds bad last few minutes of flight.

690720A. Navigation error within ± 1.0 n mi. Few Doppler memory conditions. Flight data on tape begin at 154652.

690720B. Navigation error within ± 1.2 n mi. APN-153 on memory from 1556 to 1613, 1707 to 1716, 1749 to 1804, 1941 to 1949, and 1958 to 2002.

690721E. Navigation error within ± 0.6 n mi. Very few Doppler memory conditions.

690723A. Navigation error within ± 0.6 n mi. APN-82 on memory from 1451 to 1554, 1702 to 1831, and 2040 to 2150. APN-153 on memory from 1733 to 1746.

690726A. Navigation error within ± 1.0 n mi. APN-82 on memory from 1336 to 1339, 1344 to 1350, and 1501 to 1509.

690726B. Navigation error within ± 1.0 n mi. APN-153 on memory from beginning of flight to 1200, from 1228 to 1352, 1427 to 1445, and 1447 to the end of the flight. APN-82 on memory from 1411 to 1423.

2.1.7 RFF Photographic and Radar Data and Archive Format

Radar scope photographs taken by RFF aircraft are available for selected days in 35-mm black and white positive film with synchronized time reference appearing on each frame. Data from the following radar scopes are available:

APS-20E 10-cm radar PPI scope (RRR DC-6 39C and 40C only).
WP-101 5.6-cm radar PPI scope (RFF DC-6 39C and 40C only).
RDR-ID 3.2-cm radar RHI presentation (RFF DC-6 39C and 40C only).
APS-42A 3.2-cm radar PPI scope (RFF DC-4 82E only).

Cloud photographs of cloud systems along the flight tracks of the DC-6 39C and 40C were taken by:

(a) One 16-mm forward-viewing camera time-lapsed to expose 1 frame every 2 sec with time synchronized data chamber appearing on each frame. Record is in Ektochrome color.

(b) Two 35-mm side-viewing time-lapsed cameras recording 90° each side of the heading of the aircraft with wide-angle lenses exposing 1 frame every 5 sec. Record is in 35-mm black and white positive film. Synchronized clocks appear on each frame.

The archived radar photographs are registered copies of the original film. The original cloud photographs (forward and side-viewing) are stored at the BOMAP Office. Registered copies of the originals will be made upon request.

The date, beginning time, and ending time of each reel of 35-mm radar film in table 4-17, section 4.0.0, was read from the film by the BOMAP staff. In some instances, these entries may not appear correct. For example, the time period of the radar data does not coincide with the actual flight time of the aircraft. Such anomalies can be corrected by the user through review of the preceding sections, describing the procedures followed in processing the RFF data, and of the RFF Flight Folder (sec. 2.1.8) and the RFF Photographic Quality Review Log (sec. 2.1.9).

2.1.8 RFF Flight Folder

A folder was prepared for each RFF flight, containing a complete history of the day's operation. The following is included in the folder:

Detailed Flight Program - RFF-1 Work Form. Lists date and takeoff and landing times; proposed flight patterns and actual flight patterns; takeoff data from aircraft for comparison with meteorological ground observation; and remarks pertinent to the mission.

Flight Information - RFF-2 Work Form. Contains navigation information and Event Light assignments; and crew list.

Flight Data - RFF-3 Work Form. Equipment log for meteorological and photographic equipment; recorder operations log; and dropsonde data.

Digital Station Log - RFF-4 Work Form. Contains camera operation log; digital operation; inventory of data outputs; and remarks on interruptions, power outages, etc.

Radar Station Log - RFF-5 Work Form. Log of the operation of all radar equipment and operation, with pertinent remarks.

RFF Time Check Form. Log of data chamber and clock times from radar and cloud cameras versus digital time from digital recorder with corrections for synchronization with total data package.

Electronic Status and Meteorological Systems In-Flight Data Log. Lists electronic outages and malfunctions at beginning, during, and at end of flight.

Event Log. A chronological log kept by the flight meteorologist, reporting mission progress and the time of significant events. (Useful in locating specific information on the NNV tape for programming or special interest.)

Navigation Log. A record of the aircraft position with a Doppler correction record for updating the Doppler to true position. (The corrections have been incorporated into the NNV tape.)

The RFF Flight Folders are archived on 35-mm microfilm. It is important for any user to review these folders when evaluating data from a mission. Each sheet has a flight (mission) ID number somewhere near the top of the page, as shown in the following example:

90502A,

where

9 = CY 1969

05 = May (06 for June; 07 for July)

02 = Day of month (May 2)

A = DC-6 39C (B for DC-6 40C; E for DC-4 82E).

2.1.9 RFF Photographic Quality Review Log

Following the field phase of BOMEX, RFF personnel reviewed all cloud, photopanel, and radar film acquired aboard the RFF aircraft. These log sheets indicate the quality of the processed film, any discrepancies found, and corrections of discrepancies for each mission flown during May and June.

The log sheets are archived on 35-mm microfilm and should be used in conjunction with the appropriate RFF Flight Folder (see sec. 2.1.8). The Quality Review Log sheets are arranged in chronological order. Each mission is identified in accordance with the following example:

90504APP,

where

9 = CY 1969

05 = May (06 for June; 07 for July)

04 = Day of month (May 4)

A = DC-6 39C (B for DC-6 40C; E for DC-4 82E)

PP = Photo panel (F for nose camera; R for right-side camera; L for left-side camera).

2.2.0 NAVY AND AIR FORCE AIRCRAFT DATA

Weather reconnaissance data obtained by the Navy WC-121 and the Air Force WB-47, RB-57, and WC-130 were recorded on the BOMEX RECCO Code (Aerial Meteorological Reconnaissance Reporting Code) Form. Radar scope photographs were taken by the Navy WC-121 aircraft and the Air Force WB-47 aircraft, and dropsonde data were obtained by the Air Force WC-130.

2.2.1 RECCO Data

The RECCO Code form, shown in figure 2-3, was hand-tabulated by the flight crews aboard all the Navy and Air Force aircraft. These forms were forwarded to the BOMAP Office, where they were transcribed on regular coding forms, on which the original 71 columns from RECCO were preserved intact, and only columns 72 through 80 were redesignated, as follows:

Columns 72, 73, and 74. Sea surface temperature (degrees, tenths of °C).

Column 75. Pressure indicator. If columns 34 through 36 on RECCO showed pressure in millibars, code 1 was entered in column 75 on the transcription form.

Column 76. Altitude indicator. Group 9xxx9 at the top of the page indicated the number to be entered. For example, 97779 was coded as 7 in column 76 of the transcription form.

Column 77. Aircraft identifier: Code 3 for Navy A/C 141323; 6 for Navy A/C 137896; 8 for Navy A/C 143198; 1 for earlier or only Air Force flight for that day; and 2 for second Air Force flight for that day.

Columns 78, 79, and 80. Date, e.g., 522 for May 22.

The notes referred to by number at the bottom of the form, which served as guides in encoding tha data are listed below. The tables referred to just below the column head on the form, which were also used in the encoding, are shown in figure 2-4.

Notes

9. GGgg and Y - The time the aircraft is on the vertical axis of the observation cylinder is reported for "GGgg." All elements are observed, insofar as practicable, when the aircraft is at the point of observation or in proximity thereto. The actual time of observation is the time at which the observing of all elements is completed. All times (GGgg) and the day of the week (Y) are given in Greenwich Mean Time. The day reported for Y is the day on which the observation is taken and NOT the day on which it is transmitted.

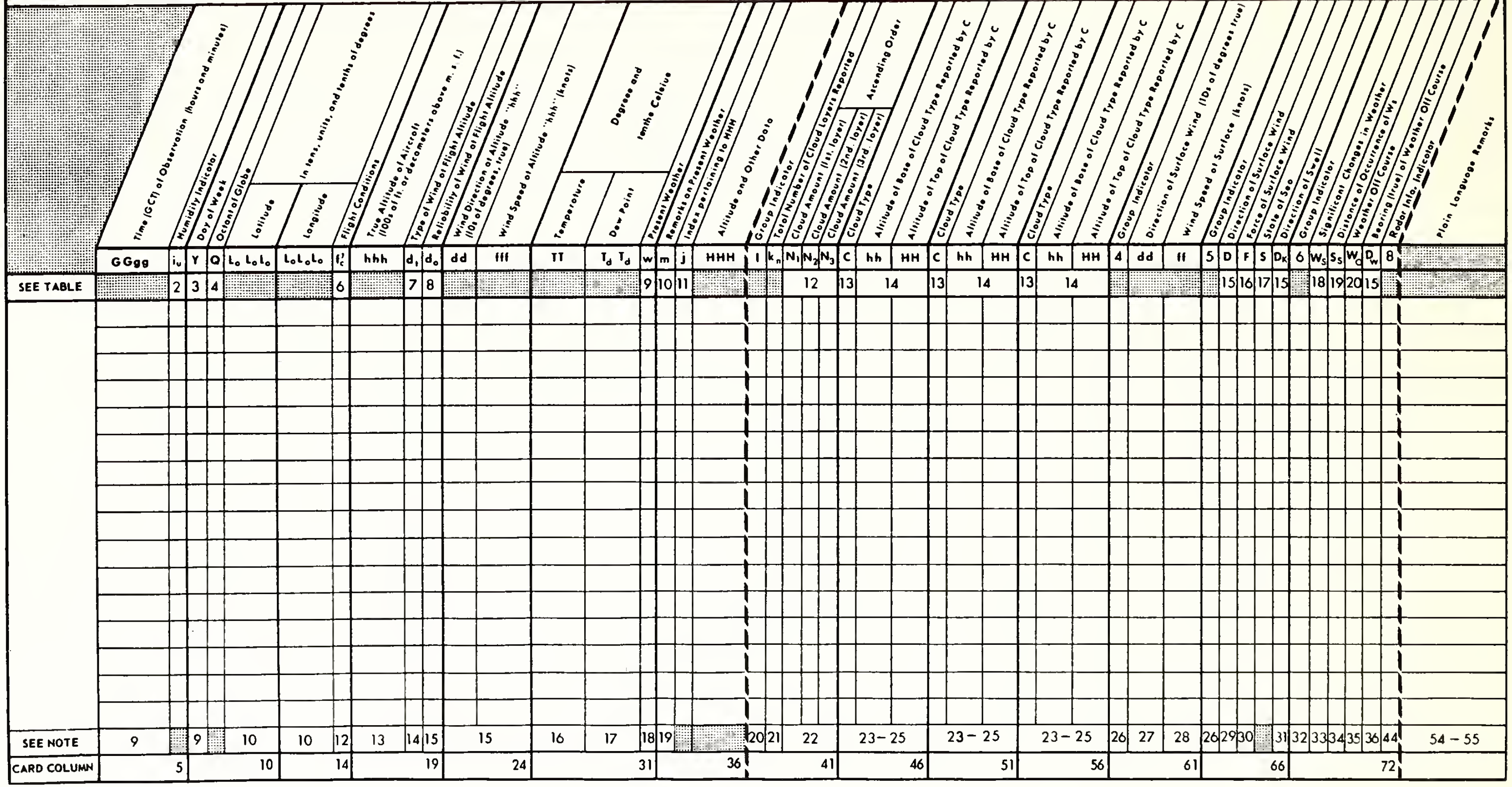


Figure 2-3. RECCO Code form.

10. $L_aL_aL_a$ and $L_oL_oL_o$ - The latitude and longitude of the point, at which the flight level observation is made, are reported for "$L_aL_aL_a$" and "$L_oL_oL_o$," respectively. Tenths of a degree are obtained by dividing the number of minutes by 6, disregarding the remainder. The hundreds digit is omitted from longitudes 100° to 180°, inclusive.

12. f_c' - The average flight condition existing during the time required to make the flight level observation is reported for "f_c'."

13. hhh - The true altitude of the aircraft at the time of the flight level observation is reported to the nearest 100-ft or 30-m level (e.g., when the aircraft is 50 ft or more above a 100-ft level, the next higher level is reported for "hhh").

14. d_t - When code figure 9 is reported, the distance over which the wind is averaged is added at the end of the message in plain language.

15. d_a and ddfff - When code figure 8 is reported for "d_a," five solidi (i.e., /////) are reported for the "ddfff" group. The complete specifications for d_a (see table 8, fig. 2-4) are:

0 90% to 100% reliable. Multiple drift with closed wind star, or small open star when winds are 50 kt or greater. Short radar wind runs.

1 75% to 100% reliable. Multiple drift with small open star or double drift or single drift with average ground speed by timing. Short radar run.

2 80% to 100% reliable. Fix-to-fix winds using the following pin-point visual fixes, radar fixes or accurate Loran fixes using good ground waves.

3 75% to 90% reliable. Fix-to-fix winds using two or three lines of positions (LOPs), either Loran, celestial, radio or sight bearings, or any combination of the above three when all lines of position are considered reliable.

4 60% to 80% reliable. Winds obtained using single drift and single LOP (speed line), air plot, etc.

5 50% to 75% reliable. Fix-to-fix winds using two or three lines of position, either Loran, celestial, radio or sight bearings, or any combination of the above three when one of the lines is not considered reliable.

6 Less than 50% reliable. Winds obtained by any of the above methods which the navigator believes to be inaccurate or of questionable accuracy.

7 No reliability. Assumed or estimated winds.

8 No wind. Navigator unable to determine a wind.

9 Not used.

16. TT - Free-air temperature (corrected for calibration, installation, and dynamic heating effects) at flight level (hhh) at the time of observation is reported for "TT" to the nearest whole degree Celsius.

When the temperature is below zero, 50 is added to the absolute value of the temperature and the sum is reported for "TT." The hundreds figure, if any, resulting from this addition is disregarded.

17. T_dT_d - When the wet-bulb temperature is below -35°C, "//" is reported for "T_dT_d." Dew point is used to indicate the moisture content of the air in United States RECCO reports (see note 16).

18. w - The specification most descriptive of the weather existing at the time of observation is reported for "w." Code figure 2 is reported when the total amount of cloud above or below the aircraft is 7/8 or more.

19. m - The information which best amplifies the present weather reported for "w" is reported for "m."

20. $1k_nN_1N_2N_3$ - If data on more than three layers of cloud are reported, a second $1k_nN_1N_2N_3$ group plus the required number of ChhHH groups are inserted in the message following the last of the first three ChhHH groups. The additional number of layers (i.e., exclusive of the first three layers) being reported is given for "k_n" in the second $1k_nN_1N_2N_3$ group. The coverage of the additional cloud layers is reported for N_1, N_2, and N_3 in the second group, as required. When no clouds exist, the $1k_nN_1N_2N_3$ and ChhHH groups are omitted from the message.

21. k_n - When clouds are present in indefinite layers (chaotic sky), code figure 9 is reported for "k_n." If it is impossible to determine that clouds exist (due to darkness or for other reasons) a "/" is reported for "k_n." When a cloud layer is present but data on the type, the extent of coverage, and altitude can not be observed, "/'s" are reported for N, C, hh, and HH, as appropriate; however, the layer will be included in the number of layers reported for "k_n" (see note 22).

22. N_1, N_2, N_3 - The amount of cloud reported for N_1, N_2, etc., is the amount in the individual layer as though no other clouds were present; i.e., the summation concept is not used. The cloud layers are reported in the message in ascending order according to altitude of the base. When code figure 9 is reported for "k_n," the value reported for "N_1" is the total amount of cloud coverage present and "//" is reported for "N_2N_3." When a "/" is reported for "k_n," "999" is reported for "$N_1N_2N_3$" (see note 21).

23. ChhHH - This group is included in the message for each layer of clouds reported by "k_n" and described by N_1, N_2, etc.

24. C - The type of cloud predominating in the layer is reported as "C."

25. hh and HHH - The average altitude of both the base and top of the cloud layer reported for "C" is reported for "hh" and "HH," respectively.

26. 4ddff and $5DFSD_k$ - Surface data are reported in this group. Surface wind data are included in each low-level report. Either or both of the groups may be included in the message if required.

27. dd - The estimated direction (true) from which the surface wind is blowing is reported for "dd" (see note 28).

28. ff - The estimated speed of the surface wind is reported for "ff." In the range of 100-199 kt, inclusive, the hundreds figure is omitted and the tens and the units values are reported for "ff" and 50 is added to the value normally reported for "dd." For speeds in excess of 199 kt, "//" is reported for "ff" and the actual speed is reported in plain language at the end of the message.

29. D - The estimated direction (true) from which the surface wind is blowing is reported for "D."

30. F - The estimated force of the surface wind is reported. When the speed exceeds Force 9, code figure 9 is reported for "F" and a plain-language remark is added at the end of the flight level portion of the message giving the actual Beaufort Force as "GALE TEN," "STORM ELEVEN," or "HURRICANE TWELVE."

31. D_K - The true direction FROM which the swell is moving is reported for "D_K." Code figure 0 is reported for "no swell" and code figure 9 is reported to indicate "confused" swell. When the waves are from several directions, the direction from which the wave of longest period is trav- traveling is reported.

32. $6W_sS_sW_cD_w$ - Two 6-groups may be included in the message to report two significant weather changes, and/or two weather phenomena off course, or two combinations thereof.

33. W_s - Significant weather changes which have occurred since the last observation, or in the preceding hour (whichever period is shorter) along the track of the aircraft are reported for "W_s."

34. S_s - The distance from the present position back to the location of the significant weather change (W_s) is reported for "S_s."

35. W_c - Any off-course weather condition of importance which is not included or implied in the specification reported for present weather, will be reported for "W_c." The information reported for "W_c" supplements the present weather (w) (see notes 2, 18, 54, and 55).

Table 2: i_u

0	°C., No humidity report
1	°C., Relative humidity
2	°C., Diff. between dry bulb and wet bulb temp.
3	°C., Diff. between dry bulb and dew point temp.
4	°C., Dew point

Table 3: Y

1	Sunday
2	Monday
3	Tuesday
4	Wednesday
5	Thursday
6	Friday
7	Saturday

Table 4: Q

0	0° - 90°W	North Latitude
1	90° - 180°W	
2	180° - 90°E	
3	90° - 0°E	
4		
5	0° - 90°W	South Latitude
6	90° - 180°W	
7	180° - 90°E	
8	90° - 0°E	

Table 6: f'_c

0	Total amount of cloud less than 1/8
1	Total cloud amount at least 1/8, with either 1/8 - 4/8 above or 1/8 - 4/8 below, or combinations thereof
2	Cloud amount more than 4/8 above and 0 - 4/8 below
3	Cloud amount 0 - 4/8 above and more than 4/8 below
4	Cloud amount more than 4/8 above and more than 4/8 below
5	Chaotic sky - many undefined layers
6	In and out of clouds, on instruments 25% of time
7	In and out of clouds, on instruments 50% of time
8	In and out of clouds, on instruments 75% of time
9	In clouds all of the time, continuous instrument flight
/	Impossible to determine due to darkness

Figure 2-4. Tables referred to on RECCO Code form that were used in encoding.

Table 7: d_t

0	Spot wind	
1	Winds averaged over 100 naut. miles preceding last fix	Last fix 25 naut. miles prior to this position.
2	Winds averaged over 200 naut. miles preceding last fix	
3	Winds averaged over 300 naut. miles preceding last fix	
4	Winds averaged over 400 naut. miles preceding last fix	
5	Winds averaged over 100 naut. miles preceding last fix	Last fix 75 naut. miles prior to this position.
6	Winds averaged over 200 naut. miles preceding last fix	
7	Winds averaged over 300 naut. miles preceding last fix	
8	Winds averaged over 400 naut. miles preceding last fix	
9	Winds averaged over more than 400 nautical miles	

Table 8: d_a

0	90% to 100% reliable
1	75% to 100% reliable
2	80% to 100% reliable
3	75% to 90% reliable
4	60% to 80% reliable
5	50% to 75% reliable
6	Less than 50% reliable
7	No reliability
8	No wind
9	Not used
	(see note 15)

Table 9: w

0	Clear (no cloud at any level)
1	Partly cloudy (scattered or broken)
2	Continuous layer(s) of cloud(s)
3	Sandstorm, duststorm, or storm of drifting snow
4	Fog, thick dust, or haze
5	Drizzle
6	Rain
7	Snow or rain and snow mixed
8	Shower(s)
9	Thunderstorm(s)

Figure 2-4. Tables referred to on RECCO Code form that were used in encoding (continued).

Table 10: m

0	No remarks
1	Light intermittent
2	Light continuous
3	Moderate intermittent
4	Moderate continuous
5	Heavy intermittent
6	Heavy continuous
7	With rain
8	With snow
9	With hail

Table 11: j

0	Surface pressure in whole millibars, thousands figure omitted
1	Altitude of 1,000 mb surface in decametres or tens of feet; if negative add 500
2	Altitude of 850 mb surface in decametres or tens of feet; if negative add 500
3	Altitude of 700 mb surface in decametres or tens of feet
4	Altitude of 500 mb surface in decametres or tens of feet
5	Altitude of 300 mb surface in decametres or tens of feet
6	Altitude of 200 mb surface in decametres or tens of feet
7	Altitude of 100 mb surface in decametres or tens of feet
8	True altitude (radio altimeter or other method) minus pressure altitude (set at 1,013 mb) in tens of feet; if negative add 500 to absolute value (e.g. -- (minus) 100 is reported as 600)
9	Altimeter sub-scale reading in whole millibars, thousands figure omitted

Figure 2-4. Tables referred to on RECCO Code form that were used in encoding (continued).

Table 12: N_1, N_2, N_3

0	Zero		Zero
1	1/10 or less, but not zero	1	Okta or less, but not zero
2	2/10 and 3/10	2	Oktas
3	4/10	3	Oktas
4	5/10	4	Oktas
5	6/10	5	Oktas
6	7/10 and 8/10	6	Oktas
7	9/10 or more, but not 10/10	7	Oktas or more, but not 8 Oktas
8	10/10	8	Oktas
9	Sky obscured, or cloud amount cannot be estimated		

Table 13: C

0	Cirrus (Ci)
1	Cirrocumulus (Cc)
2	Cirrostratus (Cs)
3	Altocumulus (Ac)
4	Altostratus (As)
5	Nimbostratus (Ns)
6	Stratocumulus (Sc)
7	Stratus (St) or Fractostratus (Fs)
8	Cumulus (Cu) or Fractocumulus (Fc)
9	Cumulonimbus (Cb)
/	Cloud not visible owing to darkness, fog, duststorm, sandstorm, or other analogous phenomena

Table 14: hh, HH, h_ih_i, H_iH_i

00	Less than 100 ft (30 m)	57	7,000 ft (2,100 m)
01	100 ft (30 m)	etc.	
02	200 ft (60 m)	78	28,000 ft (8.400 m)
03	300 ft (90 m)	79	29,000 ft (8.700 m)
04	400 ft (120 m)	80	30,000 ft (9,000 m)
05	500 ft (150 m)	81	35,000 ft (10,500 m)
etc.		82	40,000 ft (12,000 m)
49	4,900 ft (1,470 m)	etc.	
50	5,000 ft (1,500 m)	87	65,000 ft (19,500 m)
51	Not specified	88	70,000 ft (21,000 m)
etc.		89	Above 70,000 ft (21,000 m)
55	Not specified		
56	6,000 ft (1,800 m)	//	Unknown

Figure 2-4. Tables referred to on RECCO Code form that were used in encoding (continued).

Table 15: D, D_K, D_W

0	Calm or stationary (or at the station)
1	NE
2	E
3	SE
4	S
5	SW
6	W
7	NW
8	N
9	All directions, no definite direction, or unknown, or no report

Table 16: F

0	Calm
1	1 - 3 knots
2	4 - 6 knots
3	7 - 10 knots
4	11 - 16 knots
5	17 - 21 knots
6	22 - 27 knots
7	28 - 33 knots
8	34 - 40 knots
9	41 - 47 knots or over*

*See Note 30

Table 17: S

0	Calm (glassy)	
1	Calm (rippled)	(0 - 1 ft)
2	Smooth (wavelets)	(1 - 2 ft)
3	Slight	(2 - 4 ft)
4	Moderate	(4 - 8 ft)
5	Rough	(8 - 13 ft)
6	Very rough	(13 - 20 ft)
7	High	(20 - 30 ft)
8	Very high	(30 - 45 ft)
9	Phenomenal*	(Over 45 ft)

*As might exist at the center of a hurricane

Table 18: W_s

0	No change
1	Marked wind shift
2	Marked turbulence begins or ends
3	Marked temperature change (not with altitude)
4	Precipitation begins or ends
5	Change in cloud forms
6	Fog bank begins or ends
7	Warm front
8	Cold front
9	Front, type not specified

Figure 2-4. Tables referred to on RECCO Code form that were used in encoding (continued).

Table 19: S_s, S_b, S_e

0	No report
1	Reported at previous position
2	Occurring at present position
3	20 nautical miles
4	40 nautical miles
5	60 nautical miles
6	80 nautical miles
7	100 nautical miles
8	150 nautical miles
9	More than 150 nautical miles

Table 20: W_c

0	No report
1	Signs of hurricane
2	Ugly, threatening sky
3	Duststorm or sandstorm
4	Fog or ice fog
5	Waterspout
6	Cs cloud shield or bank
7	As or Ac cloud shield or bank
8	Line of heavy cumulus
9	Cb heads or thunderstorms

Figure 2-4. Tables referred to on RECCO Code form that were used in encoding (continued)

36. D_W - Code figure 9 indicates "in all directions."

44. $8d_rd_rS_r0_e$ $8w_ea_ec_ei_e$ - When radar data are observed, both the 8-groups shall be included in the report. The 8-groups may be repeated as often as necessary to report essential data.

54. Plain-language remarks may be added at the end of the message to supplement the coded data or to supply additional information of importance not provided for in the code. For example: Time of occurrence of significant weather (W_s), past weather, etc.

55. If information on past weather is added as a plain-language remark, the most significant weather encountered since the last report, or in the last hour, whichever period of time is shorter, shall be described by the remark.

2.2.1.1 RECCO Data Processing

After the transcription sheets had been completed, cards were punched and verified. The data were then checked for the following gross errors:

1. Missing time or date; time $\leq$ 2369 and date $\geq$ 501, $\leq$ 731.

2. Latitude must be between 0.0° and 20.0°, longitude between 45.0° and 68.0°.

3. Flight condition must be from 0 through 9.

4. Wind directions between 00 through 36 and wind directions of 99 are good; wind speed $\leq$ 100 kt.

5. Temperature and dew point were checked for positive values between 00.0 through 30.0 and for negative values $\geq$ 50.0. Sea temperature was checked for values between 20.0 through 35.0.

6. Altitude indicator must be 1, 2, 6, or 7; with an altitude indicator = 2 or 7, the value of altitude must be 2 and 999 decameters, respectively. With altitude indicator = 1 or 6 and aircraft indicator = 1 or 2, altitude must be between 0 to 60,000 ft; with an altitude indicator = 1 or 6 and aircraft = 3, 5, 6, or 8, altitude must be between 0 to 10,500 ft.

7. Humidity indicator must be between 0 through 4.

8. Day of the week must be between 1 through 7.

9. Octant must equal 0 only.

10. Pressure field checked for the first 32 files on tape. If pressure indicator = 1, pressure field must lie between $\geq$ 700 and $\leq$ 999. If pressure indicator = 2, pressure field is pressure altitude $\geq$ 350.

11. Clouds were checked for continuity. Layers should ascend, i.e., no third layer unless second layer present, and no second layer unless a first layer present. Height of the top of cloud should be greater than height of bottom.

12. Surface wind direction and force were checked against sea state and direction of swell for inconsistencies.

Approximately 150 to 200 observations were corrected. When an error was found, the original recording form was checked for error or data transposition between columns. A correction was made only if the inserted data could be proven correct by the BOMAP staff. If the correction could not be proven, the standard "no report" or "missing data" descriptors were used.

2.2.1.2 Characteristics of Navy and Air Force Data To Be Considered Before Use in Analysis

Although the RECCO data were checked for gross errors, as described in the preceding section, many errors of various types may have been overlooked. The user must be prepared to test the data quality thoroughly before use in scientific analysis.

The user should also note the following:

1. The date (characters 78-90) on Navy WC-121-896 RECCO flight from 1615 to 0030 GMT on 7/22/69 does not change to 7/23/69 at 0000 GMT.
2. The observations between 1452 and 1534 on Air Force WC-130-495 RECCO flight from 1400 to 2230 on 7/17/69 were written out of order.
3. The nominal frequencies of RECCO observations reported by the Navy and Air Force flight crews were:

   Navy WC-121 - Observations vary from one every 5 to 10 min in flight.
   Air Force WC-130 - Observations vary from one every 10 to 20 min in flight.
   Air Force WB-47 - Observations vary from one every 10 to 25 min in flight.
   Air Force RB-57 - Observations vary from one every 15 to 45 min in flight.

2.2.1.3 Navy and Air Force RECCO Data Archive Magnetic Tape Format

Approximately 6,000 RECCO data card images were written on the magnetic tape. The tape begins with a BCD (alpha numeric) tape identification, "ORIGINAL Hand-Tabulated BOMEX RECCO Data, Phases 1-4," followed by a physical end-of-file mark. Immediately following the end-of-file mark are 119 RECCO data files. One or more RECCO missions by one aircraft type (WC-121, WC-130,

WB-47, or RB-57) can be found within one data file. Missions flown by different aircraft types are never mixed within one file. All Navy RECCO data in chronological order by flight are first, followed by the Air Force WC-130, WB-47, and RB-57, in that order. The files are separated by an end-of-file mark, with two end-of-file marks following the last data file on tape. Contained within one data file are a variable number of records. Each record consists of 20 observations of 25 words per observation, with a 9999 written in the time word for the last record of a file and 9998 written in the time word for the last record in the last file on tape. Short records are filled with blanks (-0). Table 2-17 is an example of the archive format for one observation. The tables referred to in the "Code reference" column are the tables shown in figure 2-4, section 2.2.1. Table 2-18 describes the contents of the archive magnetic tape.

2.2.2 Navy WC-121 Aircraft Radar Photographs and Archive Format

Radar photographs were taken from the NAVY WC-121 aircraft by an APS-20 radar (frequency, 2,800 MHz) having the characteristics shown in table 2-19.

Calibration readings at the beginning of each flight were: mean peak power, 59.94 dB; sensitivity, 110.34 dBm. The scope had no range rings and no azimuth scale. A variable ring existed, however, which was maintained at 50 n mi, except where otherwise stated. The black line on the tube face pointed true north, while the electronic heading marker showed the bearing of the aircraft and could be used as a variable azimuth marker by switching the scope to "CURSOR" operation.

A radar camera with a magazine containing Plus X negative film was used. The camera rate was every four scans throughout most of the flights, except during "range series," explained below, which were taken at a rate of one photograph every two scans. After 1710 local time, the rate was switched to one every 12 scans, since little activity remained. The camera shutter opened only for 1/500 of a second, which would make the photograph dependent on scope persistence only.

In order to verify the scale of the presentation, a series of photographs were taken periodically, in which the range ring was moved out progressively from 25 n mi, at 25-n-mi intervals, to the maximum range of 200 n mi, at which the marker should not appear on the photograph at all, because it was barely visible at the edge of the scope. These "range series" were taken at the following local times: 1255; 1335; 1410 (first on 100-n-mi range, then on 200-n-mi range; several frames taken between the two with the marker at 100 n mi); 1453; 1550; 1620 (after an irregular series at 50-n-mi range with ring at 25, 35, 10, 20, 40, and again at 25 n mi); and 1900 (starting at 50 n mi because of sea clutter).*

*To convert local time to GMT, add 3 hours and 55 min.

To illustrate the manner in which the crew made observations for taking radar photographs, the following single written description of one mission (July 21, 1969) is cited.

"A band of small, disorganized echoes, about 100 n mi wide, extending through radar scope S of Barbados, with an orientation of about 290° - 70°. The aircraft crossed it southward after takeoff and flew along its southern edge until about 1330.

"At 1241 a line of larger and more organized echoes was observed, at 150 to 200 n mi, SW, oriented 310° - 130° (over the coast of Venezuela).

"Towards 1300 a line of strong and large echoes is in view, located between 11.0°N, 55.8°W, and 9.5°N, 55.4°W. Oriented 345° - 165°.

"Another echo area has an edge extending from 10°N, 56.5°W, to 6°N, 52.8°W. It consists mostly of small echoes, but contains a few 20-n-mi echoes. Although some showers are visible through the window both from this and the previous (more intense) line, none of them seems to contain large visible clouds. Isolated echoes appear N of this line.

"After 1500, it is observed that the echo formations curve towards the E. A line of moderately strong echoes is observed at 1526, centered at 6.5°N and 51.5°W, about 80 n mi long and oriented E-W.

"Another echo line, again oriented NW-SE, extends from 9.0°N, 52.0°W southeastward, through 7.2°N, 48.8°W. It contains only small echoes and is about 50 n mi wide. Aircraft crosses it between about 1620 and 1635.

"Widely scattered and small echoes still appear here and there, but organized activity no longer visible, until aircraft turns W towards Barbados.

"At about 1850, it is possible to define an edge, oriented N-S, lying at 53.3°W across our path, to an area of small echoes, which apparently extends from about 12°N to about 15°N. As we fly home along 13°N, they seem to prevail N of us, and are visible in all directions until arrival in Barbados."

The archived WC-121 aircraft radar photographs are registered copies of the original film. All dates, beginning times, and ending times for each reel of 35-mm film in table 4-17, section 4.0.0, are as read from the film by the BOMAP staff. In some instances, these entries may not appear correct, e.g., the time period of radar data does not coincide with the inflight period of the aircraft. These anomalies can usually be corrected by constraining the radar data to fit the appropriate flight period in the Navy WC-121 RECCO data, described in section 2.2.0, and correlating with the meteorological conditions encountered and reported in the RECCO data.

Table 2-17. RECCO data archive format

Word	Data	Format	Code reference
1	Time	F4.0	HHMM
2	Humidity indicator Day of week Octant of globe	F3.0	Table 2, fig. 2-2 Table 3, fig. 2-2 Table 4, fig. 2-2
3	Latitude	F3.0	LaLa.La
4	Longitude	F3.0	LoLo.Lo
5	Flight conditions	F1.0	Table 6, fig. 2-2
6	Altitude	F3.0	hhh
7	Type of wind Reliability of wind	F2.0	Table 7, fig. 2-2 Table 8, fig. 2-2
8	Wind direction	F2.0	dd
9	Wind speed	F3.0	fff
10	Temperature	F3.1	TT.T
11	Dew point	F3.1	TT.T
12	Present weather Remarks on present weather	F2.0	Table 9, fig. 2-2 Table 10, fig. 2-2

Table 2-17. RECCO data archive format (continued)

Word	Data		Format	Code reference
13	Index pertaining to HHH		F1.0	Table 11, fig. 2-2
14	HHH (altitude and other data)		F3.0	HHH
15	Cloud amount group indicator		F5.0	Table 12, fig. 2-2
	No. of cloud layers			
	Cloud amount layer 1			
	Cloud amount layer 2			
	Cloud amount layer 3			
16	C1 Cloud type		F5.0	Table 13, fig. 2-2
	Altitude of base			Table 14, fig. 2-2
	Altitude of top			Table 14, fig. 2-2
17	C2 same as C1		F5.0	
18	C3 same as C1		F5.0	
19	VSFC group indicator	1	F8.0	Notes 26, 27, 28 (see sec. 2.2.1)
	Direction of surface wind	2		dd
	Speed of surface wind	2		ff
	Group indicator	1		Note 26 (see sec. 2.2.1)
	Surface wind direction	1		Table 15, fig. 2-2
	Surface wind force	1		Table 16, fig. 2-2

Table 2-17. RECCO data archive format (continued)

Word	Data		Format	Code reference
20	AMISC state of sea	1	F7.0	Table 17, fig. 2-2
	Direction of swell	1		Table 15, fig. 2-2
	Group indicator	1		Note 36 (see sec. 2.2.1)
	Significant change in WX	1		Table 18, fig. 2-2
	Distance of occurrence	1		Table 19, fig. 2-2
	Weather off course	1		Table 20, fig. 2-2
	Bearing WX off course	1		Table 15, fig. 2-2
21	Sea surface temperature		F3.1	
22	Pressure indicator		F1.0	Redesignated columns on RECCO form (see sec. 2.2.1)
23	Altitude indicator		F1.0	
24	Aircraft indicator		F1.0	
25	Date		F3.0	

Table 2-18. Contents of RECCO data archive magnetic tape file

Date 1969	Aircraft tail No.	Nominal beginning and end times of observation (GMT)	Physical data file No.
May			
3 - 4	WC-121-896	2240 - 0710	1
4 - 5	" -323	2247 - 0853	2
9	" -198	1420 - 1935	3
9	" -896	1520 - 1925	4
10 - 11	" -198	2313 - 0811	5
11 - 12	" -896	2245 - 0914	6
12 - 13	" -198	2240 - 0758	7
26	" -896	0207 - 0835	8
26 - 27	" -896	2353 - 0846	9
27 - 28	" -896	2300 - 0708	10
31 - 6/1	" -896	2324 - 0820	11
June			
1 - 2	" -896	2359 - 0831	12
3	" -896	0001 - 0856	13
3 - 4	" -896	2350 - 0806	14
7	" -896	1215 - 1910	15
7	" -198	1055 - 2045	16
9	" -896	1035 - 2030	17
9	" -198	1035 - 2025	18

Table 2-18. Contents of RECCO data archive magnetic tape file (continued)

Date 1969	Aircraft tail No.	Nominal beginning and end times of observation (GMT)	Physical data file No.
June			
22	WC-121-323	1055 - 2155	19
22	" -198	1056 - 2200	20
23 - 24	" -198	2250 - 0945	21
25 - 26	" -323	2237 - 0940	22
29	" -323	1032 - 2045	23
29	" -198	1040 - 2040	24
30	" -198	1145 - 2140	25
30	" -323	1145 - 2146	26
July			
14	" -323	1400 - 2300	27
17	" -323	1345 - 2300	28
19 - 20	" -896	1345 - 0000	29
21	" -896	1340 - 1758	30
22 - 23	" -896	1615 - 0030	31
26	" -896	1015 - 2025	32
May			
1	WC-130-496	1242 - 1410	33
3	" -492	1139 - 1827	33
3	" -496	0131 - 0544	33
4	" -493	1210 - 1917	33
4	" -496	0136 - 0552	33

Table 2-18. Contents of RECCO data archive magnetic tape file (continued)

Date 1969	Aircraft tail No.	Nominal beginning and end times of observation (GMT)	Physical data file No.
May			
5	WC-130-495	1245 - 1943	33
5	" -496	0122 - 0542	33
6	" -494	1138 - 1826	33
6	" -495	1137 - 1530	33
7	" -496	1217 - 1840	34
9	" -495	1225 - 1833	34
10	" -494	1136 - 1833	34
11	" -493	0120 - 0528	34
11	" -495	1131 - 1826	34
12	"	0130 - 0539	34
12	"	1139 - 1832	34
13	" -493	0234 - 0638	34
13	" -494	1134 - 1842	34
13	" -496	1200 - 1530	34
14	" -493	1211 - 1830	34
25	" -494	1422 - 1820	35
26	"	0122 - 0524	35
26	"	1319 - 1721	35
27	"	0119 - 0525	35
27	"	1319 - 1714	35
28	"	0118 - 0523	35

Table 2-18. Contents of RECCO data archive magnetic tape file (continued)

Date 1969	Aircraft tail No.	Nominal beginning and end times of observation (GMT)	Physical data file No.
May			
28	WC-130	1200 - 1530	35
28	"	1328 - 1719	35
31	" -496	1325 - 1720	36
June			
1	" -493	0133 - 0541	36
1	"	1318 - 1723	36
2	"	0116 - 0522	36
2	"	1317 - 1724	36
3	"	0122 - 0529	36
3	"	1321 - 1725	36
4	"	0115 - 0518	37
4	" -492	1317 - 1640	37
7	" -494	1315 - 1718	37
8	" -495	0119 - 0525	37
8	" -493	1327 - 1748	37
9	" -495	0122 - 0530	37
9	" -495	1313 - 1717	37

Table 2-18. Contents of RECCO data archive magnetic tape file (continued)

Date 1969	Aircraft tail No.	Nominal beginning and end times of observation (GMT)	Physical data file No.
June			
10	WC-130-494	0117 - 0526	37
21	" -492	1233 - 1853	38
22	" -493	0115 - 0521	38
22	" -496	1123 - 1826	38
23	"	0114 - 0600	38
23	" -496	1126 - 1215	38
24	" -492	0115 - 0551	39
24	" -496	1128 - 1825	39
25	" -495	0120 - 0555	39
25	" -494	1130 - 1824	39
26	" -496	0057 - 0555	39
26	" -495	1201 - 1530	40
26	" -493	1141 - 1223	40
28	" -496	1140 - 1858	40
29	" -493	0157 - 0643	40
29	" -496	1200 - 1904	40
30	" -493	0116 - 0557	41
30	" -496	1052 - 1828	41
July			
1	" -494	0144 - 0634	41
1	" -493	1125 - 1827	41
3	" -496	1921 - 2319	41

Table 2-18. Contents of RECCO data archive magnetic tape file (continued)

Date 1969	Aircraft tail No.	Nominal beginning and end times of observation (GMT)	Physical data file No.
July			
13	WC-130-495	1415 - 2100	42
14	" -495	1415 - 2100	42
17	" -495	1400 - 2230	43
19	" -495	1345 - 2300	44
22	" -495	1400 - 2015	45
23	" -495	1400 - 2015	45
26	" -495	1145 - 1715	45
27	" -495	1430 - 2015	45
28	" -495	1500 - 1550	45
May			
3	WB-47-412	1402 - 1726	46
3	" -021	1400 - 1654	46
4	" -412	1256 - 1619	46
4	" -058	1349 - 1647	46
5	" -412	1247 - 1608	46
5	" -021	1347 - 1650	46
6	" -412	1414 - 1741	47
6	" -218	1407 - 1656	47
7	" -058	1255 - 1628	47
9	" -412	1256 - 1631	47

Table 2-18. Contents of RECCO data archive magnetic tape file (continued)

Date 1969	Aircraft tail No.	Nominal beginning and end times of observation (GMT)	Physical data file No.
May			
9	WB-47-	1341 - 1638	47
10	" -058	1347 - 1641	48
10	" -021	1253 - 1629	48
11	" -412	1347 - 1644	48
11	" -218	1254 - 1616	48
12	" -021	1347 - 1647	48
12	" -058	1255 - 1627	48
13	" -021	1257 - 1626	49
14	" -046	1259 - 1623	49
14	" -412	1345 - 1638	49
24	" -021	1243 - 1557	50
25	" -058	1247 - 1612	50
27	" -058	1303 - 1626	50
28	" -046	1257 - 1626	50
30	" -412	1249 - 1621	51
31	" -058	1300 - 1624	51
June			
1	" -412	1254 - 1626	52
2	" -412	1253 - 1618	52
3	" -412	1254 - 1626	52
4	" -021	1254 - 1620	52

Table 2-18. Contents of RECCO data archive magnetic tape file (continued)

Date 1969	Aircraft tail No.	Nominal beginning and end time of observation (GMT)	Physical data file No.
June			
6	WB-47-412	1258 - 1648	53
7	" -058	1305 - 1618	53
8	"	1305 - 1520	53
9	" -058	1307 - 1624	53
10	" -021	1259 - 1623	53
21	" -058	1300 - 1628	54
21	"	1340 - 1630	54
22	" -046	1247 - 1602	54
22	" -417	1347 - 1638	54
23	" -417	1407 - 1716	54
23	" -058	1358 - 1640	54
24	" -427	1255 - 1623	55
24	"	1415 - 1717	55
25	" -417	1257 - 1628	55
25	" -412	1333 - 1617	55
26	" -427	1256 - 1619	55
26	"	1344 - 1646	55
28	"	1304 - 1627	56
28	" -046	1349 - 1645	56
29	" -046	1259 - 1630	56
29	" -412	1411 - 1648	56

Table 2-18. Contents of RECCO data archive magnetic tape file (continued)

Date 1969	Aircraft tail No.	Nominal beginning and end times of observation (GMT)	Physical data file No.
June			
30	WB-47-417	1247 - 1612	56
30	" -427	1338 - 1630	56
July			
1	" -427	1257 - 1625	57
1	" -427	1347 - 1645	57
2	" -427	1248 - 1557	57
2	" -417	1348 - 1637	57
13	" -417	1351 - 1710	58
14	" -427	1430 - 1708	58
15	"	1428 - 1758	58
17	" -427	1644 - 1856	59
19	" -412	1531 - 1755	59
20	"	1123 - 1455	59
22	" -417	1525 - 1834	60
23	" -417	1430 - 1656	60
26	" -412	1538 - 1747	61
27	"	1437 - 1755	61
28	" -412	1305 - 1516	61
May			
3	RB-57-288	1425 - 1715	62
4	" -288	1423 - 1700	63
5	" -298	1310 - 1748	64

Table 2-18. Contents of RECCO data archive magnetic tape file (continued)

Date 1969	Aircraft tail No.	Nominal beginning and end times of observation (GMT)	Physical data file No.
May			
6	RB-57-298	1429 - 1659	65
7	" -288	1413 - 1655	66
8	" -293	1416 - 1657	67
9	" -298	1421 - 1756	68
10	" -288	1418 - 1651	69
11	" -293	1420 - 1655	70
12	" -298	1423 - 1657	71
13	" -298	1421 - 1656	72
14	" -298	1428 - 1652	73
15	" -293	1419 - 1700	74
24	" -296	1414 - 1600	75
24	" -299	1442 - 1737	76
25	" -296	1415 - 1605	77
26	" -296	1424 - 1612	78
27	" -299	1428 - 1600	79
28	" -299	1447 - 1623	80
30	" -296	1442 - 1626	81
31	" -299	1454 - 1628	82
31	" -296	1439 - 1613	83
June			
1	" -296	1454 - 1628	84

Table 2-18. Contents of RECCO data archive magnetic tape file (continued)

Date 1969	Aircraft tail No.	Nominal beginning and end times of observation (GMT)	Physical data file No.
June			
2	RB-57-299	1440 - 1615	85
3	" -299	1449 - 1623	86
4	" -299	1442 - 1612	87
6	" -296	1439 - 1610	88
7	" -296	1446 - 1725	89
8	" -296	1453 - 1627	90
July			
21*	" -294	1350 - 1615	91
22*	" -294	1723 - 1929	92
26*	" -294	1505 - 1715	93
27*	" -294	1525 - 1621	94
28*	" -294	1422 - 1721	95
June			
9	" -296	1443 - 1622	96
10	" -299	1447 - 1620	97
11	" -299	1408 - 1604	98
21	" -294	1412 - 1643	99
21	"	1424 - 1654	100
22	"	1425 - 1702	101
23	" -298	1516 - 1750	102
24	"	1424 - 1702	103

Table 2-18. Contents of RECCO data archive magnetic tape file (continued)

Date 1969	Aircraft tail No.	Nominal beginning and end times of observation (GMT)	Physical data file No.
June			
25	RB-57	1421 - 1643	104
26	" -294	1427 - 1658	105
27	"	1411 - 1645	106
28	" -298	1413 - 1650	107
29	" -298	1410 - 1637	108
30	" -298	1415 - 1651	109
July			
1	" -298	1424 - 1655	110
2	" -294	1424 - 1653	111
2	" -298	1423 - 1657	112
13	" -294	1305 - 1815	113
14	" -294	1428 - 1630	114
15	" -294	1447 - 1715	115
17	" -294	1324 - 1750	116
18	" -294	1426 - 1710	117
19	" -294	1430 - 1615	118
20	" -294	1703 - 1938	119

*Should have been at the end but appear on the tape in this order.

Table 2-19. Characteristics of APS-20 radar

Characteristic	Value
Transmitted power (peak)	2 MW
Wavelength	10 cm
Antenna shape	Truncated paraboloid
Horizontal beam width	1.5°
Vertical beam width	6°
Antenna gain	-30 dBm
Antenna rotation rate	6 rpm
Minimum detectable signal Linear RxR (IAGC nonlinear)	-107 dBm
Dynamic range (RxR) Linear RxR (IAGC nonlinear)	-80 dBm
Pulse repetition rate frequency	300 pulses/sec
Pulse width	2 μsec
Sensitivity time control (STC)	Varied (0 - 40%)
Range units	Nautical miles

2.2.3 Air Force WB-47 Aircraft Radar Photographs and Archive Format

During BOMEX, an Air Force WB-47 aircraft flying at an altitude of approximately 30,000 ft collected radar photographs along the flight track shown in figure 2-5. Stationed at Ramey Air Force Base, Puerto Rico, the aircraft normally passed over the island of Barbados en route to the BOMEX area. On some photographs, the island is visible as a ground pattern.

The WB-47 carried an AN/APN-59B radar, a small, light-weight, X-band airborne system designed to operate as a navigational and search radar, a weather radar, or a racon (beacon) interrogator-receiver. The indicator presentation is a 5-inch PPI display. Five range displays are available: 3 to 30 mi, with 1- and 5-mi range marks; 50 mi, with 10-mi range marks; 100 mi, with 20-mi range marks; and 240 mi, with 30-mi range marks. The start of the 3- to 30-mi range display may be delayed any distance between 15 and 210 mi in order to expand any desired portion of the longer range presentation. Iso-echo circuits are provided, but were not used during BOMEX, in order to locate the most intense portions of weather echoes. A sensitivity-time-constant (STC) function reduces the receiver gain at short ranges and increases the receiver gain as the range increases. The radar signal may be radiated as either a fan or a pencil beam. Manufactured by the Sperry Gyroscope Company, the AN/APN-59B radar has the characteristics listed in table 2-20.

The following three guidelines were specified for collection of radar photographs by the WB-47 aircraft during BOMEX:

1. One exposure every 12 scans when precipitation echoes were detected.
2. Adjusting the antenna tilt angle for maximum echo return.
3. Using 50-n-mi total range for scope setting.

A 50-n-mi display was not always used. On most frames two digits are visible just outside the boundary of the cathode ray tube (CRT) and toward the top of the CRT. These digits represent the interval of the range markers. For example, 10 would represent a range marker interval of 10 n mi. Usually either 20-n-mi (with two or three markers visible) or 10-n-mi markers (with five markers visible) are displayed. However, maximum ranges other than approximately 50 n mi and range marker intervals other than 10 or 20 n mi were used occasionally. If the range settings are uncertain for a reel of film, they can be verified in some instances from ground patterns, e.g., the island of Barbados.

The camera clock displays Greenwich time (GMT). The bearing marker appearing on the radar scope indicates the aircraft heading with respect to true north, under the assumption that proper synchronization and calibration were maintained.

The archived WB-47 aircraft radar photographs are registered copies of the original film. All dates, beginning times, and ending times for each reel of 35-mm film in table 4-17, section 4.0.0, are as read from the film by the BOMAP staff. In some instances, these entries may not appear correct, e.g., the time period of radar data does not coincide with the inflight period of the aircraft. Such anomalies can usually be corrected by

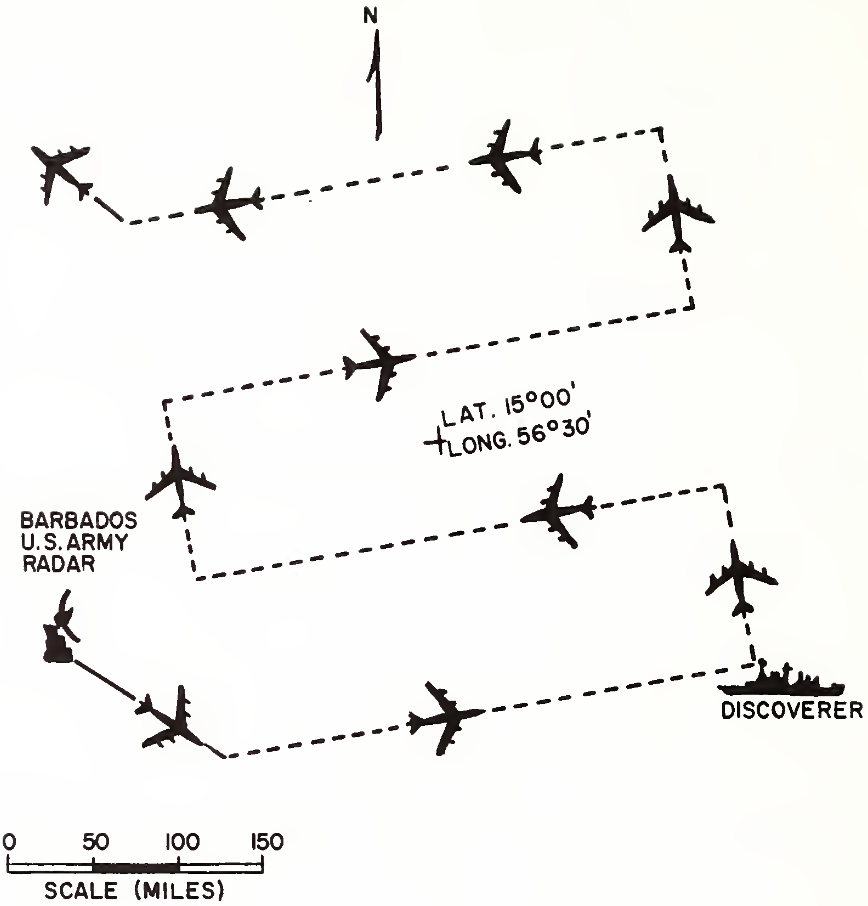


Figure 2-5. WB-47 aircraft flight track for radar photography.

Table 2-20. Characteristics of AN/APN-59B radar

Characteristic	Value
Peak power	50 kW
Wavelength	3 cm
Beam width	Pencil fan
Vertical	5° 40°
Horizontal	3.5° 5°
Beam tilt	From +10° (up) to -15° (down)
Pulse length	100 m or 1,350 m
Pulse repetition frequency	180 pps (long pulse) 1,025 pps (short pulse)
Slant range	From 80 yards to 240 n mi
Scan	
Left scan	360° counterclockwise rotation at 11 to 16 rpm
Right scan	360° clockwise rotation at 11 to 16 rpm
PPI scan	360° clockwise rotation at 11 to 16 or 49 ± 7 rpm; speed automatically determined by range and function
Sector scan for antenna AS-653A	81° ± 10°, sector dead of aircraft at 11- to 16-rpm rate
Sector scan for antenna AS-1199	Continuously variable from 30° to 180° in width, at 11 to 16 rpm; center of sector selectable over any bearing
Antenna reflector stabilization	
Pitch	From 12° (nose down) to 15° (nose up)
Roll	±30°
Azimuth reference	
Aircraft heading	Relative
Aircraft compass	Stabilized
Indicator azimuth accuracy	Indicator corresponds to antenna position within ±2°
Indicator range mark accuracy	
Range	± 0.5% (1σ)
Azimuth	± 0.3% (1σ)

constraining the radar data to fit the appropriate flight period in the WB-47 RECCO data, described in section 2.2.0, and correlating with the meteorological conditions encountered and reported in the RECCO data.

2.2.4 Air Force WC-130 Aircraft Dropsonde Data and Archive Magnetic Tape Format

During each mission, the Air Force WC-130 aircraft released eight dropsondes that had been baseline checked for temperature and humidity before flight takeoff. During dropsonde descent, temperature and humidity variations and pressure contacts were recorded on a strip chart. A pressure calibration chart was provided so that actual pressure at the contact could be determined. The strip chart was examined for significant levels, and the temperature and humidity traces were converted by calculator to meteorological units. The values, and the pressure contact, were entered on the data block of adiabatic chart WBAN-31. The data were plotted from the data block to the adiabatic chart, and thicknesses were determined so that heights of mandatory pressure could be obtained. A coded message for transmission was entered on the chart and on the BOMEX Dropsonde Recording Form, shown in figure 2-6. These forms, which were designed for 1:1 correspondence with 80-column punched cards were judged sufficiently legible for immediate key punch operation, and they provide the data set for the original processing.

Dropsonde data currently available from the BOMEX Temporary Archive consist of unverified data evaluated in accordance with standard Air Force tolerance and instructions (AWS Manual AWSM 105-1). As a result, these data contain some uncorrected human, instrumental, and computational errors, and may not represent the precision of evaluation desired for specific research applications. Occasional errors of the types listed below have been detected in the process of checking sample soundings. No reliable estimate regarding error frequency is available.

Extraction of Data From Recorder Records:

(1) Incorrect determination of pressure contacts and/or evaluation of pressure at significant levels.

(2) Incorrect temperature or humidity ordinate readings.

(3) Errors in evaluation of temperature and relative humidity, including use of incorrect baseline settings on CP-22B/UM evaluator, and reading error.

(4) In selection of significant levels, some changes in lapse rate were ignored when departure from linearity was less than or equal to 1°C, eliminating some minor isothermals or inversions.

BOMEX DROPSONDE RECORDING FORM

CARD CODE	IDENTIFICATION								CARD 01 = SURFACE CARD 02 = SIG. LVL.2					CARD 01 = 1000 MB (HEIGHT) CARD 02 = SIG. LVL.3					CARD 01 = 850 MB. (HEIGHT) CARD 02 = SIG. LVL.4					CARD 01 = 700 MB. (HEIGHT) CARD 02 = SIG. LVL. 5					CARD 01 = 500 MB. (HEIGHT) CARD 02 = SIG. LVL.6					CARD 01 = SIG. LVL. 1 CARD 02 = SIG. LVL. 7					CARD NUMBER
CARD CODE	AIRCRAFT NO.	DAY (JULIAN)	HOUR (GMT)	MINUTE	NORTH OR SOUTH	LATITUDE (TENTHS)	EAST OR WEST	LONGITUDE (TENTHS)	PRESSURE (TENTHS)	DRY BULB	TENTHS-SIGN	DEW POINT	DEPRESSION CODE	(1000 MB. HEIGHT) PRESSURE (TENTHS)	DRY BULB	TENTHS-SIGN	DEW POINT	DEPRESSION CODE	(850 MB. HEIGHT) PRESSURE (TENTHS)	DRY BULB	TENTHS-SIGN	DEW POINT	DEPRESSION CODE	(700 MB. HEIGHT) PRESSURE (TENTHS)	DRY BULB	TENTHS-SIGN	DEW POINT	DEPRESSION CODE	(500 MB. HEIGHT) PRESSURE (TENTHS)	DRY BULB	TENTHS-SIGN	DEW POINT	DEPRESSION CODE	PRESSURE (TENTHS)	DRY BULB	TENTHS-SIGN	DEW POINT	DEPRESSION CODE	CARD NUMBER
1 2	3 4 5 6 7 8	9 10 11	12 13	14	15	16 17 18	19	20 21 22 23 24	25 26 27 28	29	30	31	32 33	34 35 36 37	38	39	40	41 42	43 44 45 46	47	48	49	50 51	52 53 54 55	56	57	58	59 60	61 62 63 64	65	66	67	68 69	70 71 72 73	74	75	76	77 78	79 80

COLUMNS 1–22 REPEATED EACH CARD

COLUMNS 32–35, 41–44, 50–53 AND 59–62 ARE HEIGHT IN CARD 1. IN SUCCEEDING CARDS IT IS PRESSURE

FOR PRESSURES HIGHER THAN 999 MB. CODE UNITS TENS AND HUNDREDS VALUE

Figure 2-6. BOMEX Dropsonde Recording Form.

Baseline Calibration* and Baroswitch Setting:

(1) Occasional transposition of digits in baseline temperature and error in baseline relative humidity computations.

(2) Suspected incorrect baroswitch setting, or failure to set baroswitch, necessitating large contact corrections for evaluation of pressure from the calibration chart.

Coding and Card-Punching Errors:

(1) Errors in coding algebraic sign of temperature and other incorrect transcription, punching, and formating of coded data.

Apparent Instrumental Errors:

(1) Apparent anomalous behavior of the thermistor occasionally noted when the dropsonde is falling through cloud or precipitation, with typical examples displaying apparent cooling of thermistor below probable ambient temperature while in cloud or precipitation, and abrupt recovery to ambient temperature after emergence beneath cloud; result seen as a decreased lapse rate in cloud, and a thin layer of superadiabatic lapse rate beneath cloud.

(2) Discrepancies between the pressure corresponding to the splash contact number and the sea-level pressure frequently 10 mb or greater and occasionally as large as 30 mb, which casts some doubt on the validity of response of the baroswitch assembly, since the baroswitch setting was made near sea level. If a contact correction to offset the sea-level pressure discrepancy is not applied to the sounding, the procedures used in computing sea-level pressure for the sounding result in expansion or contraction of the 1000 mb to sea-level pressure layer by the amount of the discrepancy, with a corresponding alteration of the lapse rate.

(3) Occasional unrealistic lapse rates for the top layer as a result of use of aircraft measurements of temperature and pressure at flight level as the top level of the sounding, which suggests the possibility of occasional errors in these measurements, or of flight altitude.

(4) The radio-altimeter reading at flight level used as the height of the top level of the sounding is a geometric height measurement that is not converted to geopotential, resulting in an error of +17 to +18 gpm at the dropsonde release altitude (approximately 6500 m) at the latitude of the BOMEX array; this error carried downward in the height computations will cause a +2 mb error in computed sea-level pressure.

*Comparative soundings made over the Mt. Mitchell in some cases show apparent temperature bias (+ or -) that is relatively consistent for all soundings from a given flight. This suggests a consistent error in temperature baselining of the dropsonde instruments for that flight. In the extreme case, a bias of about +3°C of dropsonde relative to radiosonde temperature was found.

The magnetic tape format consists of six separate files, of which the sixth one constitutes the dropsonde data. When these data are requested on magnetic tape, all six files will be sent, not only the dropsonde data. The six files of information on this tape are separated from each other by end-of-file mark and followed by a double end-of-file. All information is in binary coded decimal (BCD) format, even parity, 800 bits per inch. The first file consists of 80-column card images, one card image per record, describing the formats of the data files. The other five files contain data that were either recorded manually or were read manually from strip-chart recordings; the data are in BCD card images, 50 cards (4,000 characters) per record.

The second file contains BOMEX Marine Meteorological Observations (sec. 1.3.0); the third file contains Ship Operations Data (sec. 1.4.0); the fourth file contains hand-tabulated STD Support Data (sec. 1.7.3); the fifth file contains Radiometersonde Data (sec. 1.1.3). The dropsonde data, as noted above, constitute the sixth file on the magnetic tape. Data for one sounding are on one or more cards in the following format:

Character		Information
1-22		General information, present on first card only, blank on others
	1	Should always be 8
	2-6	Aircraft ID number
	7-9	Modified Julian day (day of year)
	10-11	Hour, GMT
	12-13	Minute
	14	Latitude indicator, should always be 1 for north
	15-17	Latitude, degrees and tenths
	18	Longitude indicator, should always be 4 for west
	19-22	Longitude, degrees and tenths
23-31		Surface data on the first card; 1st, 8th, etc., significant level for other cards
	23-26	Pressure, millibars and tenths, thousands digit omitted
	27-28	Temperature, whole degrees Celsius
	29	Tenths and sign indicator for temperature (see table 2-21)
	30-31	Dew-point depression code (see table 2-22)
32-67		Blank on first card, significant level data on other cards
68-76		Significant level 1 on first card; 7th, 13th, etc., significant level on other cards
77-78		Blank
79-80		Card sequence number within the sounding

The format is: I1, I5, I3, 2I2, I1, F3.1, I1, F4.1, 6(F4.1, I2, I1, I2), 2X, I2.

Table 2-21. Code table for tenths and sign indicator

Symbol T_a = Approximate tenths value and sign of the air temperature at the standard isobaric surfaces and significant levels.

Symbol T_{ao} = Approximate tenths value and sign of the air temperature at the surface.

Symbol T_{at} = Approximate tenths value and sign of the air temperature at the level of the tropopause.

Code figure	Sign of temperature*	Temperature
0	+	0.0° and 0.1°
1	-	0.0° and 0.1°
2	+	0.2° and 0.3°
3	-	0.2° and 0.3°
4	+	0.4° and 0.5°
5	-	0.4° and 0.5°
6	+	0.6° and 0.7°
7	-	0.6° and 0.7°
8	+	0.8° and 0.9°
9	-	0.8° and 0.9°

*
+ means above zero.
- means below zero.

Table 2-22. Code table for dew-point depression

Symbol DD	= Depression of the dew point temperature at the specified pressure level.
Symbol D_oD_o	= Depression of the dew point temperature at the surface release point.
Symbol D_tD_t	= Depression of the dew point at the tropopause.

Code figure	Depression of the dew point in °C	Code figure	Depression of the dew point in °C
00	0.0	38	3.8
01	0.1	39	3.9
02	0.2	40	4.0
03	0.3	41	4.1
04	0.4	42	4.2
05	0.5	43	4.3
06	0.6	44	4.4
07	0.7	45	4.5
08	0.8	46	4.6
09	0.9	47	4.7
10	1.0	48	4.8
11	1.1	49	4.9
12	1.2	50	5
13	1.3	51	Not used
14	1.4	52	Not used
15	1.5	53	Not used
16	1.6	54	Not used
17	1.7	55	Not used
18	1.8	56	6
19	1.9	57	7
20	2.0	58	8
21	2.1	59	9
22	2.2	60	10
23	2.3	61	11
24	2.4	-	-
25	2.5	70	20
26	2.6	71	21
27	2.7	-	-
28	2.9	80	31
29	2.9	81	31
30	3.0	-	-
31	3.1	89	39
32	3.2	90	40
33	3.3	91	41
34	3.4	-	-
35	3.5	98	48
36	3.6	99	49
37	3.7		

3.0.0 ISLAND DATA ACQUISITION

Data included in the BOMEX Temporary Archive from observations made at various locations on the island of Barbados consist of radar data, rawinsonde data, and ATS-3 satellite data. For availability of island-acquired data products and ordering instructions, see section 4.0.0, Data Ordering Instructions and Costs.

3.1.0 ISLAND RADAR DATA

The U.S. Army Atmospheric Sciences Laboratory (ASL), Electronics Command (ECOM), Fort Monmouth, New Jersey, as directed by the Army Materiel Command, provided a weather radar team on Barbados to obtain quantitative estimates of precipitation and storm characteristics for mission planning and time-lapse photography of the off-center scope to study the origin, development, movement, size, and intensity of tropical weather disturbances within the range of the radar. An AN/MPS-34 van-mounted weather radar, two U.S. Army power generators, Model 4070, and auxiliary equipment were used, located on Hackleton's Cliff near the east coast of the island approximately 65 mi from the perimeter of the BOMEX square and 96 mi from the Mt. Mitchell, which was positioned at the southwest corner of the BOMEX fixed-ship array during Observation Periods I, II, and III. The antenna elevation at approximately 950 ft above mean sea level extended the radar horizon. With the antenna elevation angle at approximately zero degrees, it was possible to detect many targets at ranges up to 200 n mi or greater.

Characteristics of the AN/MPS-34 radar are listed in table 3-1. Only long-pulse operation was used.

Fifty-eight 100-ft rolls of 35-mm film containing photographs of the radar plan-position indicator (PPI) scope were obtained. A gain-step system to reduce receiver gain was used to acquire quantitative information about storm intensities. This system provided for five gain steps, calibrated to yield increments of 18 dB for step 1, 8 dB for step 2, step 3, and step 4, and 6 dB for step 5. Gain-step increments were checked for each new roll of 35-mm film and were recalibrated if any step had drifted by more than 2 dB, and the observed gain settings were recorded in an equipment log book. The procedure for calibrating both gain step and film provided a photographic record of minimum detectable signal on the film for the gain settings.

The radar film is documented in "Weather Radar Investigations on the BOMEX," a report by Dr. Michael D. Hudlow, who served as Project Scientist for the weather radar team. The report contains a quality review of each reel, describes operational and calibration procedures, and results of gain-step and film calibration, automatic camera settings for each mode of

Table 3-1. Characteristics of AN/MPS-34 radar (long pulse)

Characteristic	Probable value
Transmitted power (peak)	180 kW
Wavelength	3.2 cm
Antenna shape	Parabolic
Horizontal beam width	1°
Vertical beam width	1°
Antenna gain	26,300 (dimensionless)
Antenna rotation rate	5 rev/min
Minimum detectable signal Linear receiver	 -105 dBm
Dynamic range (receiver) Linear receiver	 17 to 20 dB
Pulse repetition frequency	186 pulses/sec
Pulse width	5×10^{-6} sec
Sensitivity time control	Not used
Range units	Statute miles

operation, and provides other significant information for film interpretation. Listed as Research and Development Technical Report ECOM-3329, "Weather Radar Investigations on the BOMEX," the document should be ordered by users from Federal agencies from:

Defense Documentation Center
ATTN: UNC-TCA
Cameron Station (Bldg. 5)
Alexandria, Virginia 22314,

and by users from non-Government groups from:

National Technical Information Service
Springfield, Virginia 22151.

3.2.0 ISLAND RAWINSONDE DATA

The U.S. Air Force Air Weather Service 6th Mobile Weather Squadron obtained upper air soundings daily from May 14 to June 4 and from July 8 to July 28 near BOMEX Field Headquarters using GMD-1A tracking and recording equipment. Standard Air Weather Service procedures were used for the rawinsonde observations, which supplemented soundings made at Seawell Airport by the Barbados Meteorological Service.

Acquired data included temperature and humidity strip charts, printouts from the GMD-1A wind-finding equipment, winds-aloft computations, and weather plotting charts. These data were evaluated and are available from the temporary archive in the form of adiabatic charts and winds-aloft computation sheets (WBAN-20).

NOTE: To obtain correct azimuth from the winds-aloft computation sheets, subtract 18° from the values shown.

3.3.0 ATS-3 DATA

For BOMEX Observation Period IV, July 11 to 28, the Hughes Aircraft Company, Aerospace Group, Space Systems Division, moved the ATS satellite ground station from Mojave, California, to Barbados for reception of ATS-3 satellite pictures to support the investigation of tropical convective systems. The Hughes Terminal, located near BOMEX Field Headquarters at Paragon House, provided continuous high-resolution satellite photographs on a real-time basis for daily planning of aircraft missions.

Located above the equator at 73°W in May, the satellite was moved progressively eastward and retained its position at 46° to 47°W during the month of July. Taken at intervals of approximately 20 min, the ATS-3 full-earth disc photographs for BOMEX Observation Period IV are available in positive transparency or print form from the temporary archive (see sec. 4.0.0).

A summary of the characteristics of the ATS-3 satellite and its two camera systems is given in The User's Guide to ATS-III Meteorological Data, published by Goddard Space Flight Center, NASA, Greenbelt, Maryland 20771.

4.0.0 DATA ORDERING INSTRUCTIONS AND COSTS

As noted in the Introduction, the BOMEX Temporary Archive has one purpose only: to distribute selected BOMEX data upon request in the form(s) in which the data now exist. If the procedures outlined below are followed, the material required to satisfy a data request will usually be shipped within 2 weeks after receipt of the order.

Various tables of information have been compiled to standardize requests for BOMEX data. These tables also provide the user with information concerning the approximate quantity of data available for each BOMEX Observation Day, the contents of the archive products, and cost of duplication to be borne by the user. A description of the tables and their use in preparing a data request follows.

Table 4-1. Reference Information to Aid in Preparation of a Data Request. The BOMEX Temporary Archive consists of two types of data: Observed Data and the Support Data required to interpret or evaluate a particular observed-data product. Table 4-1 was compiled to insure that the user is aware of all support data for an observed-data type. The user should keep in mind that most of the temporary archive products are the results of initial processing steps that are being used by BOMAP to produce the final data-processing system design. Also shown in table 4-1 are the minimum quantities of an observed-data type and the corresponding support data that can be supplied by the archive. For each observed-data type and support-data type, the appropriate columns in table 4-1 refer to the other tables to be used by the requester in selecting desired observation periods or dates, and to specify the desired archive product(s) and the appropriate support data on the data request.

Tables 4-2 through 4-9. These tables provide information on the availability of each observed-data type by BOMEX Observation Day. The tables are organized by acquisition platform or location. The information shown is a summary of the approximate observation frequency or quantity available. The tables are the source from which the user will define the observation period or dates for the data desired.

Tables 4-10 through 4-21. These tables provide the ordering specifications, inventory of each available archive product, and duplication cost.

All costs shown in tables 4-10 through 4-21 for magnetic tapes, i.e., \$60.00 per reel, are for a one-to-one duplication in the archive format. Any other desired format must first be cost-estimated before ordering data. Having reviewed the archive documentation and possibly consulted the BOMAP Office with regard to particular questions the user whould proceed as follows:

(a) Using table 4-1, note the support data required for an observed-data type and the minimum quantity of the desired observed-data product(s) that can be supplied.

(b) Define the desired observation periods or dates for which data are required for the research need at hand. This can be done for each acquisition platform or location from tables 4-2 through 4-9.

Having defined the desired data product(s) and time period from tables 4-2 through 4-9, specify from tables 4-10 through 4-21 the <u>order number</u> or <u>order designation</u> found in the far left column of each table or in the footnotes to the appropriate table, along with the description of contents for the data product(s) desired. To eliminate any possibly confusion in processing of a data request, the <u>list of requested items</u> should be organized in the same order as they are found in tables 4-10 through 4-21, i.e., the data products selected from table 4-10 should be listed first, then items selected from table 4-11, and so forth. In some cases, a user may find that more data must be ordered than is necessary. Do not specify less than the stated minimum quantity (see table 4-1) since the retrieval cost and duplication cost will be that of the minimum quantity.

Tables 4-10 through 4-21 include the duplication cost of one copy for each selected data product. The cost to the user is the sum of the individual costs for one copy of each of the data products selected. For multiple copies of any data product, multiply the duplication cost for one copy by the number of desired copies.

Advance payment is required for all work done for non-Federal institutions or agencies, private firms, universities, or individuals. All work done for Federal agencies will be on a reimbursable basis. Requests from other countries should be accompanied by a check drawn on a United States bank, if practicable, or a United States branch of a foreign bank, and payable in United States currency.

The minimum charge per order is \$3.00. Prices include shipping cost by usual "best way." Special shipping can be arranged upon request, at cost.

A few radar and microfilm reels contain less than 100 ft of film. This has been considered in establishing the overall cost of the copies and the full price is charged for each reel, regardless of its length.

Although the meteorological data are stored in the National Climatic Center (NCC), Environmental Data Service (EDS), and the oceanographic data in the National Oceanographic Data Center (NODC), EDS, a procedure has been developed within EDS that requires only a single request in response to which the user will receive information or data from both archives, if required.

Data requests or requests for information regarding data should be directed to Mr. Arthur I. Cooperman, Chief, Data Information Group, Environmental Data Service, NOAA, Silver Spring, Md. 20910. Make checks payable to "Department of Commerce, NOAA."

A sample data request is shown in figure 4-1.

Mr. Arthur I. Cooperman
Chief, Data Information Group
Environmental Data Service, NOAA
Silver Spring, Maryland 20910

Dear Mr. Cooperman:

Please send me the following from the BOMEX Temporary Archive:

1. Reels B0752, B0753, B0760, and B0754 of Boom Surface Meteorological Measurements for the Discoverer for the period May 7 through July 28, on magnetic tape, 7-channel, BCD, 800 BPI, and DOC.-1, containing the following support data: BOMEX Fixed-Ship Event Log and tabulation of all fixed-ship operations data.

2. Magnetic tape B3405, containing all RECCO Observations by the Navy and Air Force aircraft during the four BOMEX Observation Periods, and Listing of Dropsonde File from tape B9622 (computer printout) for Air Force WC-130.

3. Reels 1 through 5, non-registered copy, of AN/MPS-34 Island Radar Data on microfilm for the period May 3 - May 15. (Per your instructions, will order the support data, "Weather Radar Investigations on the BOMEX," from the National Technical Information Service.)

Enclosed please find my check for $369.00 made out to "Department of Commerce, NOAA.)

Thank you for your kind attention.

Sincerely,

Figure 4-1. Sample data request

Table 4-1. Reference information to aid in preparation of data request

Observed data	Determine availability of observed data from table number in this column	Support data required to use and/or evaluate the observed data	Minimum quantity of observed data products available	Specify observed data type from table number in this column	Minimum quantity of support data available	Specify support data from table number in this column
Fixed-Ship Rawinsonde Data	Tables 4-2 through 4-6 for the appropriate fixed ship	BOMEX Fixed-Ship Event Log Fixed-Ship Operations Data	Magnetic tape: duplicate of one magnetic tape containing rawinsonde observations for one ship observation period * Microfilm: duplicate of one reel of 35-mm film containing all rawinsondes for one ship observation period	Table 4-11	Microfilm: duplicate of one reel of 35-mm film containing the support data listed in third column	Table 4-10
Radiometersonde Data	Tables 4-2 through 4-6 for the appropriate fixed ship	BOMEX Fixed-Ship Event Log Fixed-Ship Operations Data	Magnetic tape: duplicate of one tape containing radiometersonde file Tabulated form: complete listing of contents of radiometersonde file	Table 4-12	Microfilm: duplicate of one reel of 35-mm film containing the support data listed in third column	Table 4-10

Table 4-1. Reference information to aid in preparation of data request (continued)

Observed data	Determine availability of observed data from table number in this column	Support data required to use and/or evaluate the observed data	Minimum quantity of observed data products available	Specify observed data type from table number in this column	Minimum quantity of support data available	Specify support data from table number in this column
Boom Surface Meteorological Observations	Tables 4-2 through 4-6 for the appropriate fixed ship	BOMEX Fixed-Ship Event Log Fixed-Ship Operations Data	Magnetic tape: duplicate of one magnetic tape containing all boom observations for one ship observation period Mircofilm: duplicate of one reel of 35-mm film containing all boom observations for one ship observation period	Table 4-13	Microfilm: duplicate of one reel of 35-mm film containing the support data listed in third column	Table 4-10
BOMEX Marine Meteorological Observations	Tables 4-2 through 4-6 for the appropriate fixed ship		Magnetic tape: duplicate of a magnetic tape containing marine meteorological observations as one file Tabulated form: complete listing of marine meteorological observations file from magnetic tape	Table 4-14		
Surface Pressure-Marine Microbarograms	Tables 4-2 through 4-6 for the appropriate fixed ship		Microfilm: duplicate of one reel of 35-mm film containing all microbarograms from four of the fixed ships	Table 4-14		

Table 4-1. Reference information to aid in preparation of data request (continued)

Observed data	Determine availability of observed data from table number in this column	Support data required to use and/or evaluate the observed data	Minimum quantity of observed data products available	Specify observed data type from table number in this column	Minimum quantity of support data available	Specify support data from table number in this column
Discoverer Radar Photographs	Table 4-5	BOMEX Fixed-Ship Event Log Fixed-Ship Operations Data Discoverer Weather Radar Log	Microfilm: duplicate of one 35-mm reel containing approximately 2 days of radar photographs	Table 4-17	Microfilm: duplicates of two reels of 35-mm film; one reel contains the first two support data items in the third column; the other contains the Discoverer Weather Radar Log	Table 4-10
Salinity/ Temperature Depth Data (STD 8 sps)**	Tables 4-2 and 4-5	BOMEX Fixed-Ship Event Log Fixed-Ship Operations Data STD Support Data	Magnetic tape: duplicate of one magnetic tape containing all casts from one ship for 3 to 6 days	Table 4-15	Microfilm: duplicate of one 35-mm reel containing the first two support data items in the third column; third item available in punched-card or computer-tabulation form	Table 4-10
Radio transmission Log for Salinity, Temperature, Depth, and Sound Velocity (no sound velocity recorded)	Tables 4-2 through 4-6 for the appropriate fixed ship		Microfilm: duplicate of one 35-mm reel containing all radio transmission logs from all fixed ships	Table 4-15		

Table 4-1. Reference information to aid in preparation of data request (continued)

Observed data	Determine availability of observed data from table number in this column	Support data required to use and/or evaluate the observed data	Minimum quantity of observed data products available	Specify observed data type from table number in this column	Minimum quantity of support data available	Specify support data from table number in this column
Sea Surface Temperature (NAVOCEANO CTEM) Log	Tables 4-2 through 4-6 for the appropriate fixed ship		Microfilm: duplicate of one 35-mm reel containing all CTEM logs from all fixed ships	Table 4-15		
RFF Meteorological and Renavigated Flight Track Data	Table 4-7	RFF Flight Folders	Magnetic tape: duplicate of one magnetic tape containing data for one or two missions flown by one aircraft Tabulated form: listing from magnetic tape of one mission by one aircraft	Table 4-16	Microfilm: duplicate of of one 35-mm reel containing flight folders	Table 4-10
RFF Radar Photographs	Table 4-7	RFF Photographic Quality Review Log RFF Flight Folders	Microfilm: duplicate of one 35-mm reel containing one mission by one aircraft	Table 4-17	Microfilm: duplicate of one 35-mm reel containing the two support items listed in third column	Table 4-10
RFF Aircraft Cloud Photographs	Table 4-7	RFF Photographic Quality Review Log RFF Flight Folders	Black and white 35-mm film: duplicate of one 800-ft reel containing one or more missions flown by one aircraft (right or left side camera) Color 16-mm film: duplicate of one 400-ft reel containing one mission flown by one aircraft (nose camera)	Table 4-18	Microfilm: duplicate one 35-mm reel containing the two support items listed in third column	Table 4-10

Table 4.1. Reference information to aid in preparation of data request (continued)

Observed data	Determine availability of observed data from table number in this column	Support data required to use and/or evaluate the observed data	Minimum quantity of observed data products available	Specify observed data type from table number in this column	Minimum quantity of support data available	Specify support data from table number in this column
Navy and Air Force Aircraft RECCO Observations	Table 4-8		Magnetic tape: duplicate of one magnetic tape containing all RECCO observations by all Navy and Air Force aircraft Tabulated form: complete listing of all observations by one Navy or Air Force aircraft type	Table 4-19		
Navy WC-121 Radar Photographs	Table 4-8		Microfilm: duplicate of one 35-mm reel containing one or more aircraft missions	Table 4-17		
Air Force WB-47 Radar Photographs	Table 4-8		Microfilm: duplicate of one 35-mm reel containing all radar photographs from one mission	Table 4-17		
Air Force WC-130 Dropsonde Data	Table 4-8		Magnetic tape: duplicate of one magnetic tape containing all dropsonde observations as one of several files Tabulated form: complete listing of dropsonde file from magnetic tape	Table 4-19		

Table 4.1. Reference information to aid in preparation of data request (continued)

Observed data	Determine availability of observed data from table number in this column	Support data required to use and/or evaluate the observed data	Minimum quantity of observed data products available	Specify observed data type from table number in this column	Minimum quantity of support data available	Specify support data from table number in this column
U. S. Army Island Radar Photographs	Table 4-9	"Weather Radar Investigations on the BOMEX"	Microfilm: duplicate of one 35-mm reel containing 1 to 3 days of radar photographs	Table 4-17	A publication avail- from Defense Documentation Center or National Technical Information Service	See sec. 3.1.0 for address
Island Rawinsonde Observations	Table 4-9		Manuscript: hard-copy reproduction of adiabatic chart and upper air computation sheet for one observation	Table 4-20		
Hughes ATS-3 Data (Period IV)	Table 4-9		Photograph (positive transparency): duplicate of one ATS-3 "full-earth" negative in positive form	Table 4-21		

*Ship observation period: All observations of the appropriate type from any one of the five fixed ships for one BOMEX Observation Period (14 to 14 days).

**The support data indicated here for the STD 8-sps data may not in all cases be required; the processed 8-sps data include relevant information from the support items listed.

Table 4-2. Fixed-ship observed data availability
Ship: Oceanographer

Date 1969: Calendar date	Date 1969: Julian day	Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	*Discoverer* Weather Radar Photographs: No. of photos	Salinity/ Temperature/ Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
May 1	121					1				
2	122					1				
3	123	12		20	16	1			5	11
4	124	14		19	15	1			4	14
5	125	8		20	11	1			4	13
6	126	3		20	14	1			4	12
7	127	6		22	10	1			4	12
8	128			2	1	1				
9	129	7		22	9	1			4	12
10	130	14		23	13	1			3	10
11	131	15		24	15	1			4	11
12	132	13		23	14	1			3	9
13	133	13		23	15	1			4	15
14	134	5		19	7	1			3	13
15	135	1			2	1			1	22
16	136					1				8
17	137									
18	138									
19	139									
20	140									
21	141									
22	142					1				6
23	143					1			2	24
24	144	2		23	4	1			1	17
25	145	10		22	13	1			4	12
26	146	8		23	15	1			4	13
27	147	7		20	14	1			3	11
28	148	11		20	14	1			5	13
29	149	1		2	1	1				
30	150	5		22	8	1			4	13
31	151	11		22	13	1			4	12

Table 4-2. Fixed-ship observed data availability
Ship: Oceanographer
(continued)

Date 1969 Calendar date	Date 1969 Julian day	Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	*Discoverer* Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
June 1	152	14		23	15	1			4	12
2	153	10		22	15	1			4	12
3	154	13		22	15	1			3	12
4	155	12		22	13	1			4	12
5	156	1		1	1	1				
6	157	5		22	9	1			4	12
7	158	13		22	15	1			4	12
8	159	3		22	8	1			4	12
9	160	13		22	15	1			3	12
10	161	3		7	4	1			2	4
11	162					1				
12	163									
13	164									
14	165									
15	166									
16	167									
17	168									
18	169									
19	170					1				7
20	171	1			1	1		1	1	21
21	172	3		21	8	1		3	2	13
22	173	12		22	4	1		8	4	13
23	174	11		22	14	1		8	4	12
24	175	14		22	15	1		8	4	12
25	176	12		22	15	1		8	4	12
26	177	9		22	13	1		8	4	12
27	178	1		2	1	1				
28	179	9		22	12			8	4	12
29	130	13		22	15			8	4	12
30	131	5		11	5			4	2	5

Table 4-2. Fixed-ship observed data availability
Ship: Oceanographer

(continued)

Date 1969 Calendar date	Date 1969 Julian day	Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	*Discoverer* Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
July 1	182									
2	183									
3	184									
4	185									
5	186									
6	187									
7	188									
8	189									
9	190									
10	191					1				5
11	192					1		2	2	24
12	193	3		14	5	1		6	2	17
13	194	6		22	8	1		8	3	14
14	195	3		22	8	1		4	4	12
15	196	1		21	7	1		3	3	13
16	197	1		2	1	1				
17	198	3		23	8	1		7	4	6
18	199	8		22	8	1		7	4	20
19	200	7		22	8	1		9	4	14
20	201	8		22	8	1		8	4	14
21	202	6		22	8	1		9	4	14
22	203	6		22	8	1		8	4	14
23	204	7		22	8	1		9	4	14
24	205			14	4	1		2	2	7
25	206	8		20	8	1		7	2	6
26	207	4		22	8	1		9	4	22
27	208	4		16	7	1		8	3	17
28	209	6			7	1		7		24
29	210	2						2		15

Table 4-3. Fixed-ship observed data availability
Ship: Rainier

Date 1969		Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	*Discoverer* Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
Calendar date	Julian day									
May 1	121	2		7	9	1				
2	122	3		17	15	1			1	10
3	123	12	1	18	15	1			1	13
4	124	13	2	19	15	1				13
5	125	4	2	17	8	1				12
6	126	13	1	22	15	1				12
7	127	6	1	23	11	1				12
8	128					1				
9	129	7	1	23	10	1				12
10	130	14	1	21	15	1				12
11	131	12	1	21	15	1				12
12	132	13	1	22	15	1				12
13	133	13	1	22	15	1				12
14	134	4	2	18	8	1				14
15	135									
16	136									
17	137									
18	138									
19	139									
20	140									
21	141									
22	142					1				
23	143					1				
24	144	7	1	21	10	1			4	10
25	145	9	2	21	14	1			4	12
26	146	9	1	22	15	1			4	11
27	147			21	14	1			3	18
28	148	2		21	14	1			3	6
29	149			1		1				12
30	150	4	1	21	8	1			4	12
31	**151**	**10**	**2**	**21**	**14**	**1**			**4**	**12**

Table 4-3. Fixed-ship observed data availability
Ship: Rainier

(continued)

Date 1969 Calendar date	Julian day	Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	*Discoverer* Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
June 1	152	14	1	22	15	1			4	12
2	153	13	1	22	15	1			4	12
3	154	13	1	21	15	1			4	12
4	155	11		22	13	1			4	12
5	156			1		1				12
6	157	4	2	22	10	1			4	12
7	158	9	1	21	15	1			2	12
8	159	2	1	21	8	1			4	12
9	160	10	1	22	15	1			3	12
10	161			9	4	1			1	4
11	162									
12	163									
13	164									
14	165									
15	166									
16	167									
17	168									
18	169									
19	170					1				6
20	171	1	1		1	1				24
21	172	1	1	21	8	1		4	3	12
22	173	12		22	14	1		4	3	12
23	174	14	1	22	15	1		4	4	12
24	175	15	2	22	16	1		4	4	12
25	176	14	1	22	15	1		3	3	12
26	177	11		21	13	1		4	4	12
27	178			1		1		1		12
28	179	7	2	23	13	1		4	4	12
29	180	13	1	21	15	1		3	3	12
30	181	12	1	22	15	1		4	3	12

Table 4-3. Fixed-ship data availability
Ship: Rainier

(continued)

Date 1969: Calendar date	Date 1969: Julian day	Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	Discoverer Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
July 1	182	11	1	22	14	1		4	4	12
2	183			13	4			1	3	6
3	184									
4	185									
5	186									
6	187									
7	188									
8	189									
9	190									8
10	191					1			2	24
11	192	3	1	12	6	1			1	15
12	193	4	1	20	8	1			4	12
13	194	7	1	21	8	1			4	12
14	195	5	1	21	8	1			3	12
15	196	2		21	7	1			2	16
16	197	1	1	2	1	1			4	4
17	198	4	2	22	8	1			4	11
18	199	6	2	21	8	1			4	12
19	200	6	2	21	8	1			4	12
20	201	7	2	22	8	1				12
21	202	3	1	22	7	1			4	12
22	203	5	2	21	9	1			3	12
23	204	7	2	22	8	1			4	12
24	205	1		13	3	1			2	12
25	206	5	1	19	8	1			3	12
26	207	4	1	22	8	1			4	12
27	208	5	1	21	8	1			4	12
28	209	6		22	7	1			4	12
29	210								2	24
30	211									10

Table 4-4. Fixed-ship observed data availability
Ship: Mt. Mitchell

Date 1969 Calendar date	Julian day	Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	Discoverer Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
May 1	121									
2	122	1		2	2	1				
3	123	13		19	15	1			2	12
4	124	7		12	9	1			3	6
5	125	3		14	7	1			3	11
6	126	11		19	14	1			3	12
7	127	6		23	12	1			4	12
8	128			1		1				
9	129	7		23	12	1			4	12
10	130	13		23	15	1			4	12
11	131	15		23	15	1			4	12
12	132	10		23	15	1			4	12
13	133	12		23	15	1			4	12
14	134	3		21	8	1			3	12
15	135			6						
16	136									
17	137									
18	138									
19	139									
20	140									
21	141									
22	142									
23	143					1			2	5
24	144	5		22	9	1			4	11
25	145	9		22	14	1			4	12
26	146	6		20	14	1			4	12
27	147	12		20	15	1			4	12
28	148	11		23	14	1			4	12
29	149			1						
30	150	5		20	9	1			4	12
31	151	10		19	12	1			4	12

Table 4-4. Fixed-ship observed data availability
Ship: Mt. Mitchell

(continued)

Date 1969 Calendar date	Date 1969 Julian day	Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	Discoverer Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
June 1	152	14		20	15	1			4	12
2	153	12		23	14	1			4	12
3	154	11		21	15	1			3	12
4	155	14		22	14	1			4	12
5	156			1		1				
6	157	6		19	10	1			4	12
7	158	10		22	15	1			3	12
8	159	4		23	7	1			4	12
9	160	15		22	16	1			4	12
10	161	3		7	3	1			2	3
11	162									
12	163									
13	164									
14	165									
15	166									
16	167									
17	168									
18	169									
19	170									1
20	171					1		4		11
21	172	4		4	8	1		4	4	12
22	173	10		21	15	1		4	4	12
23	174	12		22	16	1		4	4	12
24	175	11		23	14	1		4	4	12
25	176	14		23	15	1		4	4	12
26	177	11		23	13	1		4	4	12
27	178			1		1		1		
28	179	8		21	12	1		3	4	12
29	180	7		23	15	1		3	3	12
30	181	12		23	14	1		4	4	12

Table 4-4. Fixed-ship observed data availability
Ship: Mt. Mitchell

(continued)

Date 1969: Calendar date	Date 1969: Julian day	Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	Discoverer Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
July 1	182	11		23	14	1		4		
2	183	1		14	5	1		4		
3	184							1		
4	185									
5	186									
6	187									
7	188									
8	189									
9	190									
10	191					1			4	11
11	192	1		2	1	1			1	1
12	193	1		9	3	1			1	5
13	194	8		21	8	1			4	12
14	195	5		21	7	1			4	12
15	196	6		23	7	1			4	12
16	197			1		1				
17	198	4		21	8	1			4	12
18	199	8		22	8	1			4	12
19	200	6		22	8	1			3	12
20	201	7		23	8	1			4	12
21	202	5		23	8	1			4	12
22	203	6		23	8	1			4	12
23	204	7		23	7	1			4	12
24	205	1		12	4	1			2	6
25	206	6		20	7	1			3	12
26	207	4		22	7	1			4	12
27	208	5		23	8	1			4	12
28	209	6		12	8	1			6	12
29	210	2				1			3	9

Table 4-5. Fixed-ship observed data availability
Ship: Discoverer

Date 1969			Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	Discoverer Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
Calendar date		Julian day									
May	1	121									
	2	122									
	3	123					1				
	4	124					1				
	5	125					1				
	6	126					1				
	7	127	6		21	11	1			4	12
	8	128	1	1	1		1				
	9	129	7	1	22	10	1			4	12
	10	130	6		20	16	1			4	12
	11	131	10	1	20	15	1			4	13
	12	132	9	2	22	15	1			4	12
	13	133	8	1	23	15	1			4	12
	14	134	3	3	22	9	1			4	12
	15	135				1	1				
	16	136									
	17	137									
	18	138									
	19	139									
	20	140									
	21	141									
	22	142					1				
	23	143					1				
	24	144	8	1	5	10	1	890		3	10
	25	145					1	354			11
	26	146					1				4
	27	147	7	1	15	13	1	335		3	10
	28	148	8		22	13	1	519		3	11
	29	149	1	1	1	1	1	685			
	30	150	2	1	14	6	1	479		4	12
	31	151	10	1	19	12	1	496		4	12

Table 4-5. Fixed-ship observed data availability
Ship: Discoverer

(continued)

Date 1969 Calendar date	Julian day	Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	Discoverer Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
June 1	152	14	1	23	15	1	484		4	12
2	153	14	1	22	13	1	511		4	6
3	154	13	1	21	15	1	493		4	10
4	155	12		22	13	1	512		4	10
5	156	1	1	2	1	1	250			
6	157	6	1	22	8	1	464		4	12
7	158	13	1	23	15	1	26		4	12
8	159	6	1	22	8	1			4	12
9	160	15	2	23	15	1			4	12
10	161	4		7	5	1			4	10
11	162					1				6
12	163					1				
13	164					1				
14	165									
15	166									
16	167									
17	168									
18	169						258			
19	170					1				4
20	171	1				1	55			12
21	172	1	1	21	8	1	512	8	4	12
22	173	10	1	23	16	1	381	3	2	12
23	174	15	1	21	14	1	454	8	4	12
24	175	10	1	21	15	1	387	8	4	12
25	176	15	1	22	15	1	518	9	4	12
26	177	11		21	13	1	620	8	4	6
27	178	1	1	1	1	1	1115	2		
28	179	8		21	12	1	638	7	2	
29	180	14	1	19	15	1	449	9	4	12
30	181	14	1	20	14	1	465	8	4	6

Table 4-5. Fixed-ship observed data availability
Ship: Discoverer

(continued)

Date 1969 Calendar date	Date 1969 Julian day	Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	Discoverer Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
July 1	182	10	1	17	14	1	542	8	4	12
2	183	2		14	4	1	419	9	3	4
3	184					1				6
4	185					1				
5	186					1				
6	187									
7	188									
8	189									
9	190					1				3
10	191					1			2	12
11	192	5	2	9	5	1	477	6	3	10
12	193	4	1	22	8	1	615	9	4	12
13	194	8	1	21	8	1	572	8	4	12
14	195	4	1	21	8	1	429	8	4	12
15	196	6		22	7	1	529	6	3	10
16	197	1	1	1	1	1	1072			
17	198	4	2	21	8	1	762	8	4	12
18	199	6	1	22	8	1	534	8	4	12
19	200	8	2	22	4	1	414	8	4	12
20	201	7		22	8	1	459	8	4	10
21	202	10	2	22	8	1	482	8	4	12
22	203	6	2	22	8	1	609	8	4	12
23	204	10	2	21	4	1	515	8	4	12
24	205	3	1	13	8	1	843	1	1	
25	206	9	1	19	8	1	634	7	3	12
26	207	4	3	22	8	1	783	5	3	12
27	208	4	2	22	8	1	657	5	4	12
28	209	9		20	1	1	397		1	

Table 4-6. Fixed-ship observed data availability
Ship: Rockaway

Date 1969: Calendar date	Date 1969: Julian day	Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	*Discoverer* Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
May 1	121	1			14					
2	122	7	1		15					
3	123	7	2		15				4	12
4	124	10	1		15				4	12
5	125	4	2		8				4	12
6	126	8	2		15				4	12
7	127	4		18	11				4	12
8	128	1	1	8	8					
9	129	6	1	18	10				4	12
10	130	6	1	16	15				4	12
11	131	8	1	7	15				4	12
12	132	7	2	21	11				2	12
13	133	6		21	8				4	12
14	134	4	2	17	7				4	12
15	135	1			2				1	
16	136				1					
17	137									
18	138									
19	139									
20	140									
21	141									
22	142									
23	143		1							
24	144	4	1		7				1	6
25	145	2	1	9	9				4	12
26	146	6	1	22	8				4	12
27	147	3	1	22	8				4	12
28	148	6		22	7				4	12
29	149	1	1	1	5					
30	150	5	1	22	7				4	12
31	151	6	1	22	7				4	12

Table 4-6. Fixed-ship observed data availability
Ship: Rockaway

(continued)

Date 1969 Calendar date	Julian day	Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	*Discoverer* Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
June 1	152	8	1	23	8				5	12
2	153	6	1	22	7				2	12
3	154			2					1	4
4	155	4		13	5				2	17
5	156	1	1	1	1					6
6	157	6	1	22	7				4	12
7	158	8	1	22	8				4	12
8	159	3		23	6				4	12
9	160	9	2	22	9				4	12
10	161	2		8	2				4	12
11	162								2	
12	163									
13	164									
14	165									
15	166									
16	167									
17	168									
18	169									
19	170							1		
20	171	1	1		1			3		12
21	172	2	1	11	4			7	3	12
22	173	8	1	20	9			8	4	12
23	174	6	1	21	8			8	4	12
24	175	7	1	22	8			8	4	12
25	176	8	1	20	8			5	4	12
26	177	6		20	6			7	4	12
27	178	1	1	1	1			0		6
28	179	6	1	21	6			8	4	12
29	180	6	1	19	8			5	4	12
30	181	2	1	11	5			3	2	12

Table 4-6. Fixed-ship observed data availability
Ship: Rockaway

(continued)

Date 1969		Fixed-Ship Rawinsonde Data: No. of observations	Radiometersonde Data: No. of observations	Boom Surface Meteorological Measurements: No. of hours	BOMEX Marine Meteorological Observations: No. of observations	Surface Pressure--Marine Microbarograms: No. of charts	*Discoverer* Weather Radar Photographs: No. of photos	Salinity/Temperature/Depth Data (STD 8 sps): No. of casts	Radio Transmission Log for STD: No. of casts	Sea Surface Temperature: No. of observations
Calendar date	Julian day									
July 1	182	7	1	22	7			8	4	12
2	183	2		11	2			1	3	6
3	184									
4	185									
5	186									
6	187									
7	188									
8	189									
9	190								1	
10	191								3	12
11	192	5	2	18	5				4	12
12	193	4		19	4				4	12
13	194	7	1	22	8				4	12
14	195	4	1	22	5				4	12
15	196	6		21	6				4	11
16	197	1	1		1					6
17	198	2	2	8	5				4	12
18	199	8	3	21	8				4	12
19	200	8	2	22	8				4	12
20	201	7	2	23	8				4	15
21	202	9	3	22	9				4	12
22	203	6	2	22	6				4	13
23	204	8	1	23	8				3	13
24	205	2		12	2				2	6
25	206	7	1	23	8				3	12
26	207	4	1	22					4	12
27	208	5	1	22					4	12
28	209	5		17					1	12

Table 4-7. RFF aircraft observed data availability

Date: 1969 Calendar date	Date: 1969 Julian day	RFF DC-6 (39C): Aircraft meteorological and re-navigated flight track data: No. of flight hrs.	RFF DC-6 (39C): Radar RDR-1	RFF DC-6 (39C): Radar WP-101	RFF DC-6 (39C): Radar APS-20	RFF DC-6 (39C): Cloud photographs Side	RFF DC-6 (39C): Cloud photographs Nose	RFF DC-6 (40C): Aircraft meteorological and re-navigated flight track data: No. of flight hrs.	RFF DC-6 (40C): Radar RDR-1	RFF DC-6 (40C): Radar WP-101	RFF DC-6 (40C): Radar APS-20	RFF DC-6 (40C): Cloud photographs Side	RFF DC-6 (40C): Cloud photographs Nose	RFF DC-4 (82E): Aircraft meteorological and re-navigated flight track data: No. of flight hrs.	RFF DC-4 (82E): Radar APS-42
May 1	121														
2	122														
3	123														
4	124	7.7				X	X	11.8	X			X	X	11.6	X
5	125	7.3				X	X								
6	126														
7	127														
8	128														
9	129							6.3	X	X	X	X	X	6.2	X
10	130	8.3				X	X								
11	131	7.2				X	X	11.3	X		X	X	X	11.3	X
12	132	10.1	X	X		X	X	10.3	X			X	X		
13	133														
14	134	7.8				X	X								
15	135														
16	136														
17	137	5.3				X	X								
18	138														
19	139														
20	140														
21	141														
22	142	6.1				X	X								
23	143														
24	144	7.5				X	X								
25	145														
26	146	8.0				X	X	10.7	X	X		X	X	10.6	X
27	147	10.1				X	X	10.9	X	X		X	X	10.9	X
28	148														
29	149	3.5				X									
30	150														

Table 4-7. RFF aircraft observed data availability
(continued)

Date		RFF DC-6 (39C)						RFF DC-6 (40C)						RFF DC-4 (82E)	
1969 Calendar date	Julian day	Aircraft meteorological and re-navigated flight track data: No. of flight hrs.	Radar RDR-1	Radar WP-101	Radar APS-20	Cloud photographs Side	Cloud photographs Nose	Aircraft meteorological and re-navigated flight track data: No. of flight hrs.	Radar RDR-1	Radar WP-101	Radar APS-20	Cloud photographs Side	Cloud photographs Nose	Aircraft meteorological and re-navigated flight track data: No. of flight hrs.	Radar APS-42
July 1	182														
2	183	8.3				X	X							8.8	X
3	184														
4	185														
5	186														
6	187														
7	188														
8	189														
9	190														
10	191														
11	192			X	X			11.3	X	X	X	X			
12	193														
13	194	10.8	X			X	X	10.7	X	X	X	X	X	5.3	X
14	195	11.1	X		X		X	11.0	X	X	X		X		
15	196													5.7	X
16	197														
17	198														
18	199	9.4	X		X	X	X	10.7	X	X	X	X	X	10.7	X
19	200														
20	201	7.1					X	7.5	X	X	X		X		
21	202													5.0	X
22	203														
23	204	11.1				X	X	10.1		X	X	X	X	11.2	X
24	205														
25	206	12.3	X												
26	207	11.6	X			X	X	10.3	X	X	X		X	11.2	X
27	208							0.6						3.6	
28	209	9.8	X	X			X								

X - Radar or cloud photographs taken.

Table 4-8. Navy and Air Force aircraft observed data availability

Date		Navy WC-121		AF WB-47			AF WC-130			AF RB-57	
1969		RECCO Observations	Radar	RECCO Observations		Radar	RECCO Observations		Dropsonde Data	RECCO Observations	
Calendar date	Julian day	Total flight hours	No. of hours of observations	Total flight hours	No. of flights	No. of hours of observations	Total flight hours	No. of flights	No. of observations	Total flight hours	No. of flights
May 1	121										
2	122										
3	123	9.7		13	2	4	11	1	4	6	1
4	124	11.4		12	2	5	14	2	16	5	1
5	125			11	2	6	19	2	8	7	1
6	126			12	2	3	23	3	4	5	1
7	127			11	2	6	10	1		5	1
8	128									5	1
9	129	12.9		12	2	3	10	1		6	1
10	130	10.8		11	2	5	11	1		5	1
11	131	12.5		11	2	4	18	2		5	1
12	132	11.1		11	2	5	18	2	8	5	1
13	133			6	1	5	27	3	21	5	1
14	134			13	2	6	10	1		6	1
15	135									6	1
16	136										
17	137										
18	138										
19	139										
20	140										
21	141										
22	142										
23	143										
24	144			6	1	5				11	2
25	145	1.1		7	1	4	8	1	8	5	1
26	146	18.4					15	2	16	5	1
27	147	9.6		6	1	4	16	2	16	5	1
28	148			6	1	3	28	4	24	5	1
29	149										
30	150			6	1	6				6	1
31	151	10.2		6	1	5	8	1	8	11	2

Table 4-8. Navy and Air Force aircraft observed data availability (continued)

Date		Navy WC-121		AF WB-47			AF WC-130			AF RB-57	
1969		RECCO Observations	Radar	RECCO Observations		Radar	RECCO Observations		Dropsonde Data	RECCO Observations	
Calendar date	Julian day	Total flight hours	No. of hours of observation	Total flight hours	No. of flights	No. of hours of observation	Total flight hours	No. of flights	No. of observations	Total flight hours	No. of flights
June 1	152	10.0		6	1	4	15	2	4	5	1
2	153	10.3		6	1	5	16	2	15	4	1
3	154	10.0		6	1	5	16	2	13	5	1
4	155			6	1	6	20	3	14	5	1
5	156										
6	157			6	1	4				5	1
7	158	21.0		6	1	4	8	1	8	5	1
8	159			5	1		16	2	14	5	1
9	160	21.0		6	1	6	15	2	14	5	1
10	161			6	1		7	1	8	5	1
11	162									7	1
12	163										
13	164										
14	165										
15	166										
16	167										
17	168										
18	169										
19	170										
20	171										
21	172			12	2	3	10	1		10	2
22	173	23.6		11	2		11	1	16	6	1
23	174	11.6		12	2	4	14	3	6	6	1
24	175			11	2	5	29	3	16	5	1
25	176	11.6		12	2	6	19	2	16	5	1
26	177			11	2	5	22	3	15	5	1
27	178									6	1
28	179			11	2	6	11	1	8	6	1
29	180	21.6		11	2	4	20	2	15	5	1
30	181	21.1		9	2	5	19	2	16	6	1

Table 4-8. Navy and Air Force aircraft observed data availability (continued)

Date		Navy WC-121		AF WB-47			AF WC-130			AF RB-57	
1969		RECCO Observations	Radar	RECCO Observations		Radar	RECCO Observations		Dropsonde Data	RECCO Observations	
Calendar date	Julian day	Total flight hours	No. of hours of observation	Total flight hours	No. of flights	No. of hours of observation	Total flight hours	No. of flights	No. of observations	Total flight hours	No. of flights
July 1	182			11	2	6	28	3	16	5	1
2	183			11	2		4	1	1	11	2
3	184						7	1	4		
4	185						2	1			
5	186										
6	187										
7	188										
8	189										
9	190										
10	191										
11	192										
12	193										
13	194			6	1	4	8	1	7	7	1
14	195	10.8	7	5	1	3	8	1		5	1
15	196			6	1	3	2	1		4	1
16	197										
17	198	10.1		5	1		10	1	3	6	1
18	199									6	1
19	200	11.6	11	6	1	5	10	1	11	5	1
20	201			7	1	4				5	1
21	202	5.1	5							5	1
22	203	9.0	9	5	1		8	1	13	5	1
23	204			6	1	6	6	1			
24	205										
25	206										
26	207	10.8	10	5	1	4	7	1	3	5	1
27	208			5	1		7	1	2	3	1
28	209			4	1	3	3	1		5	1

Table 4-9. Island observed data availability

Date 1969		Island radar data	Island upper air observations		Hughes ATS-3 data
Calendar date	Julian day	No. of hours of operation	Rawinsonde No. of observations	Radiometersonde No. of Observations	No. of photographs
May 2	123		1	1	
3	123	13	1	1	
4	124	3	1	1	
5	125	10	1	1	
6	126	15	1	1	
7	127	18	1	1	
8	128	8	1	1	
9	129	7	1	1	
10	130	18	1	1	
11	131	12	1	1	
12	132	21	2	2	
13	133	19	2	2	
14	134	17	1	2	
15	135	21	3	1	
16	136		2	2	
17	137		2	2	
18	138		2	2	
19	139		2		
20	140	3	2	1	
21	141	23	2		
22	142	23	2		
23	143	15	2		
24	144	9	1		
25	145	11	2		
26	146	21	2		
27	147	19	3		
28	148	13	1		
29	149	16	2		
30	150	21	2		
31	151	22	2		

Table 4-9. Island observed data availability (continued)

Date 1969		Island radar data	Island upper air observations		Hughes ATS-3 data
Calendar date	Julian day	No. of hours of operation	Rawinsonde No. of observations	Radiometersonde No. of observations	No. of photographs
June 1	152	23	2	2	
2	153	17	2	2	
3	154	20	2	2	
4	155	16	2	2	
5	156	22	2	2	
6	157	21	2	2	
7	158	18	2	2	
8	159	17	2	2	
9	160	19	2	2	
10	161	9	2	2	
11	162		2	2	
12	163		2	2	
13	164		2	2	
14	165		2	2	
15	166	10	2	2	
16	167	23	3	2	
17	168	16	2	2	
18	169	22	2	2	
19	170	21	2	2	
20	171	19	2	2	
21	172	18	2	2	
22	173	15	2	2	
23	174	17	2	2	
24	175	23	2	2	
25	176	22	2	2	
26	177	15	2	2	
27	178	20	2	2	
28	179	18	2	2	
29	180	14	2	2	
30	181	22	2	2	

Date 1969		Island radar data	Island upper air observations		Hughes ATS-3 Data
Calendar date	Julian day	No. of hours of operation	Rawinsonde No. of observations	Radiometersonde No. of observations	No. of photographs
July 1	182	17	2	2	
2	183		2	2	
3	184		2	2	
4	185		2	2	
5	186		2	2	
6	187		2	2	
7	188		2	2	
8	189	13	2	2	
9	190	22	2	2	
10	191	19	2	2	3
11	192	12	2	2	11
12	193	21	2	2	13
13	194	21	2	2	16
14	195	9	2	2	6
15	196	14	2	2	15
16	197	17	2	2	
17	198	21	2	2	9
18	199	21	2	2	17
19	200	21	4	4	7
20	201	12	4	4	18
21	202	20	4	4	15
22	203	22	4	4	23
23	204	20	4	4	11
24	205	22	2	2	15
25	206	21	4	4	13
26	207	19	4	4	27
27	208	10	4	4	23
28	209		3	3	6

Table 4-10. Support data inventory

Order by designation in this column	Contents	Duplication cost	Availability date for distribution
DOC.-1*	BOMEX Fixed-Ship Event Log Tabulation of all Fixed-Ship Operations Data	$ 9.00	2/1/71
DOC.-2	RFF Photographic Quality Review Log RFF Flight Folders	$ 9.00	2/1/71
DOC.-3**	_Discoverer_ Weather Radar Log	$ 9.00	2/1/71
STD Support Data in punched-card form	All STD Support Data for all STD casts from all five fixed ships (one punched card per cast)	$15.00	2/1/71
Listing of STD Support Data	Computer tabulation of the STD Support Data from the punched cards of all STD casts from all five fixed ships	$ 5.00	2/1/71

*Fixed-Ship Operations Data are also available on magnetic tape B9622 as one of five data files on this tape. Specify tape B9622, and one of the following: (a) 7 Channel; BCD; 200, 556, or 800 BPI; or (b) 9 Channel; ERDIC; 800 BPI. Cost is $60.00 (includes cost of magnetic tape).

**This reel also includes the Surface Pressure - Marine Microbarograms and the CTEM Logs (see tables 4-14 and 4-15).

Table 4-11. Fixed-Ship Rawinsonde Data inventory

Order by reel No. in this column	Name of ship	Archived form of data*	Recorded format of data	BOMEX Observation Period	Date and time of first observation, 1969		Date and time of last observation, 1969		Duplication cost	Availability date for distribution
					Date	Hr:Min	Date	Hr:Min		
B0723	<u>Oceanographer</u>	Magnetic Tape	Time series of processed rawinsonde 5-sec data points. Each rawinsonde observation is one tape file	I	May 3	0305	May 15	0256	$60.00 per magnetic tape (includes cost of reel)	2/1/71
B0724	"	"		II	May 24	1250	June 10	0600		"
B0725	"	"	"	III	June 21	2320	June 30	0901	"	"
B0726	"	"	"	IV	July 12	1129	July 29	0318	"	"
B0727	<u>Rainier</u>	"	"	I	May 1	1038	May 14	1754	"	"
B0728	"	"	"	II	May 24	0310	June 9	1644	"	"
B0729	"	"	"	III	June 21	2356	July 1	1920	"	"
B0730	"	"	"	IV	July 11	1141	July 28	2120	"	"
B0731	<u>Mt. Mitchell</u>	"	"	I	May 2	1907	May 14	1806	"	"
B0732	"	"	"	II	May 24	0306	June 10	0601	"	"
B0733	"	"	"	III	June 21	0114	July 2	0001	"	"
B0734	"	"	"	IV	July 11	0004	July 29	0627	"	"
B0735	<u>Discoverer</u>	"	"	I	May 7	0440	May 14	1759	"	"
B0736	"	"	"	II	May 24	0030	June 10	0742	"	"
B0737	"	"	"	III	June 20	2325	July 2	1123	"	"
B0738	"	"	"	IV	July 11	0129	July 28	2119	"	"
B0739	<u>Rockaway</u>	"	"	I	May 7	1159	May 15	0245	"	"
B0740	"	"	"	II	May 24	0259	June 10	0603	"	"
B0741	"	"	"	III	June 21	2323	July 2	1136	"	"
B0742	"	"	"	IV	July 11	0004	July 28	2029	"	"

Table 4-11. Fixed-Ship Rawinsonde Data inventory (continued)

Order by reel No. in this column	Name of ship	Archived form of data *	Recorded format of data	BOMEX Ob- servation Period	Date and time of first ob- servation, 1969		Date and time of last ob- servation, 1969		Duplication cost	Availability date for distribution
					Date	Hr:Min	Date	Hr:Min		
LP400	Oceanographer	Microfilm	Tabulation of 5-sec data points for ob- servation and plots of T, RH vs. P(mb)	I	May 3	0305	May 15	0256	$ 9.00 per reel	2/1/71
	"	"	and U, V vs. P(mb).							
LP401	"	"	"	II	May 24	1250	June 10	0600	"	"
LP402	"	"	"	III	June 20	2320	June 30	0901	"	"
LP403	"	"	"	IV	July 12	1129	July 29	0318	"	"
LP404	Rainier	"	"	I	May 1	1038	May 14	1754	"	"
LP405	"	"	"	II	May 24	0310	June 9	1644	"	"
LP406	"	"	"	III	June 20	2356	July 1	1920	"	"
LP407	"	"	"	IV	July 11	1141	July 28	2120	"	"
LP408	Mt. Mitchell	"	"	I	May 2	1907	May 14	1806	"	"
LP409	"	"	"	II	May 24	0306	June 10	0601	"	"
LP410	"	"	"	III	June 21	0011	July 2	0001	"	"
LP411	"	"	"	IV	July 11	0004	July 27	0009	"	"
LP412	Discoverer	"	"	I	May 7	0440	May 14	1759	"	"
LP413	"	"	"	II	May 24	0030	June 10	0742	"	"
LP414	"	"	"	III	June 19	2325	July 2	1123	"	"
LP415	"	"	"	IV	July 11	0129	July 28	2119	"	"
LP416	Rockaway	"	"	I	May 1	1159	May 15	0245	"	"
LP417	"	"	"	II	May 24	0259	June 10	0603	"	"
LP418	"	"	"	III	June 20	2323	July 2	1136	"	"
LP419	"	"	"	IV	July 11	0428	July 28	1452	"	"

*When ordering magnetic tape, specify (A) 7 Channel; BCD; 200,556, or 800 BPI; or (B) 9 Channel; EBCDIC; 800 BPI.

Table 4-12. Radiometersonde Data inventory

Order by designation in this column	Contents	Duplication cost	Availability date for distribution
B9622 *	Magnetic tape containing all observations from fixed ships _Discoverer_, _Rainier_, and _Rockaway_, and observations near Paragon House, Barbados	$60.00 (includes cost of tape)	2/1/71
Printout of Radiometersonde File from tape B9622	Listing of entire Radiometersonde File from tape B9622	$15.00	2/1/71

*Radiometersonde Data is only one of five files on this tape. When ordering magnetic tape, specify (A) 7 channel; BCD; 200, 556, or 800 BPI; or (B) 9 channel; EBCDIC; 800 BPI.

Table 4-13. Boom Surface Meteorological Measurements inventory

Order by reel No. in this column	Name of ship	Archived form of data *	Recorded format of data	BOMEX Observation Period	Date and time of first observation, 1969		Date and time of last observation, 1969		Duplication cost	Availability date for distribution
					Date	Hr:Min	Date	Hr:Min		
B0743	Oceanographer	Magnetic tape	Time series of 30-sec data points; one observation day is one tape file	I	May 3	0003	May 15	0003	$60.00 per magnetic tape (includes cost of reel)	2/1/71
B0744	"	"	"	II	May 24	1236	June 10	2358		"
B0761	"	"	"	III	June 21	2322	June 30	2327	"	"
B0745	"	"	"	IV	July 11	1005	July 29	0000	"	"
B0746	Rainier	"	"	I	May 1	1004	May 14	2343	"	"
B0747	"	"	"	II	May 24	2332	June 10	2355	"	"
B0758	"	"	"	III	June 21	2356	July 1	2348	"	"
B0748	"	"	"	IV	July 11	0733	July 28	2315	"	"
B0749	Mt. Mitchell	"	"	I	May 3	0104	May 14	0003	"	"
B0750	"	"	"	II	May 24	2355	June 10	2359	"	"
B0759	"	"	"	III	June 21	2139	July 2	0000	"	"
B0751	"	"	"	IV	July 10	2340	July 28	2352	"	"
B0752	Discoverer	"	"	I	May 7	0104	May 15	2327	"	"
B0753	"	"	"	II	May 24	1700	June 10	2332	"	"
B0760	"	"	"	III	June 20	2349	July 2	2356	"	"
B0754	"	"	"	IV	July 11	1511	July 28	2320	"	"
B0755	Rockaway	"	"	I	May 2	0006	May 14	0750	"	"
B0756	"	"	"	II	May 24	2330	June 10	2328	"	"
30762	"	"	"	III	June 21	2103	July 2	2317	"	"
30757	"	"	"	IV	July 11	0517	July 28	2332	"	"

Table 4-13. Boom Surface Meteorological Measurements inventory (continued)

Order by reel No. in this column	Name of ship	Archived form of data *	Recorded format of data	BOMEX Observation Period	Date and time of first observation, 1969		Date and time of last observation, 1969		Duplication cost	Availability date for distribution
					Date	Hr:Min	Date	Hr:Min		
LB420	Oceanographer	35-mm microfilm	Tabulation of 30-sec data points, 10-min averages, and 30-min averages by observation day	I	May 3	0003	May 15	0430	$9.00 per reel	2/1/71
LB421	"	"	"	II	May 24	1236	June 10	1700	"	"
LB422	"	"	"	III	June 20	2322	June 30	1000	"	"
LB423	"	"	"	IV	July 11	1005	July 29	0430	"	"
LB424	Rainier	"	"	I	May 1	1004	May 14	2000	"	"
LB425	"	"	"	II	May 23	2332	June 10	0830	"	"
LB526	"	"	"	III	June 21	2356	July 1	2230	"	"
LB427	"	"	"	IV	July 11	0733	July 28	2300	"	"
LB428	Mt. Mitchell	"	"	I	May 3	0104	May 14	2330	"	"
LB429	"	"	"	II	May 23	2355	June 10	0630	"	"
LB430	"	"	"	III	June 22	2139	July 2	1330	"	"
LB431	"	"	"	IV	July 11	2340	July 28	1130	"	"
LB432	Discoverer	"	"	I	May 7	0104	May 15	0330	"	"
LB433	"	"	"	II	May 24	1700	June 10	0730	"	"
LB434	"	"	"	III	June 19	2349	July 2	1330	"	"
LB435	"	"	"	IV	July 11	1511	July 28	2200	"	"
LB436	Rockaway	"	"	I	May 2	0006	May 14	1730	"	"
LB437	"	"	"	II	May 23	2330	June 10	0730	"	"
LB438	"	"	"	III	June 20	2103	July 2	1230	"	"
LB439	"	"	"	IV	July 11	0517	July 28	1700	"	"

*When ordering magnetic tape, specify (A) 7 channel; BCD; 200, 556, or 800 BPI; or (B) 9 channel; EBCDIC; 800 BPI.

Table 4-14. BOMEX Marine Meteorological Observations and Surface Pressure - Marine Microbarogram Data inventory

Order by designation in this column	Archived form of data *	Observed data type	Contents	Duplication cost	Availability date for distribution
B9622	Magnetic tape	BOMEX Marine Meteorological Observations	BOMEX Marine Meteorological Observations from all fixed ships for all Observation Periods as one file on tape	$60.00 (includes cost of tape)	2/1/71
Listing of file from tape B9622	Computer listing of magnetic tape file	BOMEX Marine Meteorological Observations	Printout of complete contents of BOMEX Marine Meteorological Observations File from tape B9622	$15.00	2/1/71
DOC.-3	35-mm microfilm	Surface Pressure-Marine Microbarograms	This reel contains all Marine Microbarograms from the <u>Oceanographer</u>, <u>Rainier</u>, <u>Mt. Mitchell</u>, and <u>Discoverer</u> for all Observation Periods	$ 9.00	2/1/71

* When ordering magnetic tape, specify (A) 7 channel; BCD; 200, 556, or 800 BPI; or (B) 9 channel; EBCDIC; 800 BPI.

Table 4-15. Fixed-Ship Salinity/Temperature/Depth and Sea Surface Temperature Data inventory

Order by designation in this column	Name of ship	Archived form of data *	Contents	Date and time of first observation, 1969		Date and time of last observation, 1969		Duplication cost	Availability date for distribution
				Date	Hr:Min	Date	Hr:Min		
B9045	Oceanographer	Magnetic tape	STD 8-sps Data	June 20	1022	June 24	2106	$60.00 per magnetic tape (includes cost of reel)	2/1/71
									"
B9046	"	"	"	25	0053	30	0910	"	"
B9008	"	"	"	July 11	1011	July 17	2111	"	"
B9009	"	"	"	18	0056	21	2223	"	"
B9010	"	"	"	22	0057	25	2123	"	"
B9011	"	"	"	26	0056	29	0316	"	"
B9044	Rainier	"	"	June 21	0118	July 22	0121	"	"
B9047	Mt. Mitchell	"	"	June 20		July 3	0212	"	"
B9040	Discoverer	"	"	June 21	0100	June 26	2100	"	"
B9041	"	"	"	27	0059	July 2	1156	"	"
B9005	"	"	"	July 11	0558	17	2100	"	"
B9006	"	"	"	18	0000	2	2100	"	"
B9007	"	"	"	24	0000	27	1520	"	"
B9042	Rockaway	"	"	June 19	2143	June 25	1225	"	"
B9043	"	"	"	26	0304	July 2	1228	"	"

Table 4-15. Fixed-Ship Salinity/Temperature/Depth and Sea Surface Temperature Data inventory (continued)

Order by designation in this column	Name of ship	Archived form of data *	Contents	Date and time of first observation, 1969		Date and time of last observation, 1969		Duplication cost	Availability date for distribution
				Date	Hr:Min	Date	Hr:Min		
DOC.-4	All five fixed ships	35-mm microfilm	All Radio Transmission Logs for Salinity/Temperature/Depth (one sheet per cast; four casts per ship per day)	May 1		July 28		$ 9.00	2/1/71
DOC.-3	All five fixed ships	35-mm microfilm	All CTEM Log sheets, two per day (one of three items on this reel; see tables 4-10 and 4-14)	May 1		July 28		$ 9.00	"

When ordering magnetic tape, specify (A) 7 channel; BCD; 556 or 800 BPI; or (B) 9 channel; EBCDIC; 800 BPI. (On special request, a 7-channel, BCD, 200-BPI magnetic tape copy is available at a cost of $180.00 per order number in the far left column.) A computer tabulation of all 8-sps data on one of the magnetic tapes (B9005 to B9011) is also available. When ordering a printout, specify magnetic tape number, ship's name, date and time of first observation, and date and time of last observation. Example: "Listing of B9005, Discoverer, July 11/0558, July 17/2100." Cost is $30.00 per magnetic tape printout.

Table 4-16. RFF Meteorological and Renavigated Flight Track Data inventory
Part 1: RFF DC-6 39C

Order by reel No. in this column *	Archived form of data	Mission No.	Type and name of aircraft	Date and time of start of mission		Date and time of end of mission		Mission name**	Duplication cost	Availability date for distribution
				Calendar date	Hr: Min. (GMT)	Calendar date	Hr: Min. (GMT)			
B2830	Magnetic tape	690504A	DC-6 39C	May 4	1450	May 4	2143	Water vapor	$60.00 per	3/ 8/71
B2830	"	690505A	"	5	1457	5	2051	flux	magnetic	"
B2831	"	690510A	"	10	0949	10	1744	"	tape	"
B2831	"	690511A	"	11	1511	11	2127	"	(includes	"
B2832	"	690512A	"	12	1137	12	2125	LID-B	cost of reel)	"
B2832	"	690514A	"	14	1216	14	1941	Water	"	"
B2833	"	690517A	"	17	1409	17	1903	vapor	"	"
B2833	"	690522A	"	22	1743	22	2315	flux	"	"
B2834	"	690524A	"	24	1842	25	0147	"	"	3/22/71
B2834	"	690526A	"	26	1452	26	2227	"	"	"
B2835	"	690527A	"	27	1321	27	2211	"	"	"
B2835	"	690529A	"	29	1946	29	2248	"	"	
B2836	"	690601A	"	June 1	1312	June 1	1604	"	"	3/ 8/71
B2836	"	690601A	"	1	1705	1	2214	"	"	"
B2837	"	690603A	"	3	1314	3	1926	"	"	"
B2837	"	690607A	"	7	1005	7	2212	LID-C	"	"
B2838	"	690609A	"	9	1007	9	2147	"	"	"
B2838	"	690621A	"	21	1712	21	2147	Water vapor flux	"	"
B2839	"	690622A	"	22	1012	22	2207	LID-C	"	2/25/71
B2839	"	690623A	"	23	2212	24	0910	LIN-C	"	"
B2840	"	690625A	"	25	2245	26	0941	"	"	"
B2840	"	690628A	"	28	1327	28	2026	Radiation	"	"
B2841	"	690629A	"	29	1337	29	2005	Water vapor flux	" "	" "

Table 4-16. RFF Meteorological and Renavigated Flight Track Data inventory
Part 1: RFF DC-6 39C
(continued)

Order by reel No. in this column *	Archived form of data	Mission No.	Type and name of aircraft	Date and time of start of mission: Calendar date	Date and time of start of mission: Hr: Min. (GMT)	Date and time of end of mission: Calendar date	Date and time of end of mission: Hr: Min. (GMT)	Mission name**	Duplication cost	Availability date for distribution
B2841	Magnetic tape	690630A	DC-6 39C	June 30	1405	June 30	2215	WVF-LID-D	$60.00 per magnetic tape (in-cludes cost of reel)	2/25/71
B2842	"	690702A	"	July 2	1234	July 2	2022	Radiation		"
B2842	"	690713A	"	13	1238	13	2221	ITCZ		"
B2843	"	690714A	"	14	1324	14	2354	Synoptic		"
B2843	"	690718A	"	18	1116	18	2013	Radiation		"
B2844	"	690720A	"	20	1520	20	2144	Cloud streets	"	"
B2844	"	690723A	"	23	1240	23	2319	ITCZ-Rad.	"	"
B2845	"	690725A	"	25	1011	25	2152	ITCZ-Recife	"	"
B2845	"	690726A	"	26	1310	27	0018	ITCZ-Return	"	"
B2846	"	690728A	"	28	1431	28	2352	Synoptic disturb.	"	"

*Two separate RFF missions are written on one magnetic tape, except for those missions having only one reel number. A computer tabulation of the processed data for one mission flown by one RFF aircraft is also available. When ordering a tabulation, specify the reel number in the far left column and the mission number in the third column from the left. Example: "Listing of reel number, B2830, flight number, 690504A." Cost of tabulation is $45.00 per mission. When ordering magnetic tape, specify one of the following, along with reel number in far left column: (A) 7 Channel; BCD; 200, 556, 800 BPI; or (B) 9 Channel; EBCDIC; 800 BPI.

**No gust probe data are contained on the magnetic tapes for water vapor flux missions flown by the RFF DC-6 39C. The data shown for these missions represent only the standard aircraft meteorological and navigation parameters. The gust probe data are being evaluated and will be placed in the temporary archive when available.

Table 4-16. RFF Meteorological and Renavigated Flight Track Data inventory
Part 2: RFF DC-6 40C

Order by reel No. in this column *	Archived form of data	Mission No.	Type and name of aircraft	Date and time of start of mission: Calendar date	Date and time of start of mission: Hr: Min. (GMT)	Date and time of end of mission: Calendar date	Date and time of end of mission: Hr: Min. (GMT)	Mission name	Duplication cost	Availability date for distribution
B2847	Magnetic tape	690504B	DC-6 40C	May 4	1045	May 4	2150	MOD LID Doppler comparison	$60.00 per magnetic	3/ 8/71
B2847		690509B	"	9	1421	9	1939			"
B2848	"	690511B	"	11	1030	11	2119	LID-A	tape	"
B2848	"	690512B	"	12	1136	12	2125	"	(includes	"
B2849	"	690526B		26	1105	26	2113	"	cost of	"
B2849	"	690527B	"	27	1102	27	2120	"	reel)	"
B2850	"	690601B	"	June 1	1108	June 1	2147	"	"	"
B2850	"	690602B	"	2	1112	2	2139	"	"	"
B2851	"	690603B	"	3	1100	3	2127	"	"	"
B2851	"	690607B	"	7	1030	7	2106	LID-G	"	"
B2852	"	690609B	"	9	1034	9	2101	"	"	2/25/71
B2852	"	690622B	"	22	1034	22	2122	"	"	"
B2853	"	690623B	"	23	2213	24	0910	LIN-D	"	"
B2853	"	690625B	"	25	2246	26	0941	"	"	"
B2854	"	690629B	"	29	1014	29	2113	LID-C	"	"
B2854	"	690630B	"	30	1110	30	2215	"	"	"
B2855	"	690711B	"	July 11	1112	July 11	2212	ITCZ-crossing	"	3/22/71

Table 4-16. RFF Meteorological and Renavigated Flight Track Data inventory
Part 2: RFF DC-6 40C

(continued)

Order by reel No. in this column *	Archived form of data	Mission No.	Type and name of aircraft	Date and time of start of mission: Calendar date	Date and time of start of mission: Hr:Min (GMT)	Date and time of end of mission: Calendar date	Date and time of end of mission: Hr:Min (GMT)	Mission name	Duplication cost	Availability date for distribution
B2855	Magnetic tape	690713B	DC-6 40C	July 13	1237	July 13	2221	ITCZ	$60.00 per magnetic tape (includes cost of reel)	2/25/71
B2856	"	690714B	"	14	1326	14	2352	Synoptic		"
B2856	"	690718B	"	18	1118	18	2127	Radiation		"
B2857	"	690720B	"	20	1521	20	2222	Cloud streets		"
B2857	"	690723B	"	23	1240	23	2227	ITCZ-radiation		"
B2858	"	690726B	"	26	1011	26	2006	Synoptic disturb.		"

*Two separate RFF missions are written on one magnetic tape, except for those missions having only one reel number. A computer tabulation of the processed data for one mission flown by one RFF aircraft is also available. When ordering a tabulation, specify the reel number in the far left column and the mission number in the third column from the left. Example: "Listing of reel number, B2830, flight number, 690504A,". Cost of tabulation is $45.00 per mission. When ordering magnetic tape, specify one of the following, along with reel number in far left column: (A) 7 Channel; BCD; 200, 556, 800 BPI; or (B) 9 Channel; EBCDIC; 800 BPI.

Table 4-16. RFF Meteorological and Renavigated Flight Track Data inventory
Part 3: RFF DC-4 82E

Order by reel No. in this column *	Archived form of data	Mission No.	Type and name of aircraft	Date and time of start of mission		Date and time of end of mission		Mission name	Duplication cost	Availability date for distribution
				Calendar date	Hr: Min. (GMT)	Calendar date	Hr: Min. (GMT)			
B2859	Magnetic tape	690504E	DC-4 82E	May 4	1045	May 4	2145	MOD. LID Doppler-compar.	$60.00 per magnetic tape	3/ 8/71
B2859		690509E	"	9	1421	9	1939			"
B2860	"	690511E	"	11	1029	11	2119	LID-B	tape (includes cost of reel)	"
B2860	"	690526E	"	26	1102	26	2113	"		"
B2861	"	690527E	"	27	1102	27	2119	"		"
B2861	"	690601E	"	June 1	1108	June 1	2146	"		"
B2862	"	690602E	"	2	1111	2	2139	"	"	"
B2862	"	690603E	"	3	1059	3	2127	"	"	"
B2863	"	690607E	"	7	1004	7	2112	LID-D	"	"
B2863	"	690609E	"	9	1007	9	2147	"	"	"
B2864	"	690622E	"	22	1012	22	2122	"	"	2/25/71
B2864	"	690623E	"	23	2253	24	0659	LIN-E	"	"
B2865	"	690625E	"	25	2234	26	0949	LIN-F	"	"
B2865	"	690628E	"	28	1327	28	2026	Radiation	"	"
B2866	"	690629E	"	29	1013	29	2112	LID-D	"	3/22/71
B2866	"	690702E	"	July 2	1233	July 2	2059	Radiation	"	"
B2867	"	690713E	"	13	1237	13	1658	ITCZ	"	2/25/71
B2867	"	690715E	"	15	0947	15	1502	Synoptic	"	"
B2868	"	690718E	"	18	1115	18	2126	Radiation	"	"

Table 4-16. RFF Meteorological and Renvigated Flight Track Data inventory
Part 3: RFF DC-4 82E
(continued)

Order by reel No. in this column *	Archived form of data	Mission No.	Type and name of aircraft	Date and time of start of mission: Calendar date	Date and time of start of mission: Hr: Min. (GMT)	Date and time of end of mission: Calendar date	Date and time of end of mission: Hr: Min. (GMT)	Mission name	Duplication cost	Availability date for distribution
B2868	Magnetic tape	690721E	DC-4 82E	July 21	1312	July 21	1723	Subcloud layer	$60.00 per	2/25/71
B2869	"	690723E	"	23	1239	23	2318	ITCZ-Rad.	magnetic tape	"
B2869	"	690726E	"	26	0916	26	1959	Synoptic disturb.	(includes cost of	"
B2870	"	690727E	"	27	1339	27	1651	"	reel)	"

*Two separate RFF missions are written on one magnetic tape, except for those missions having only one reel number. A computer tabulation of the processed data for one mission flown by one RFF aircraft is also available. When ordering a tabulation, specify the reel number in the far left column and the mission number in the third column from the left. Example: "Listing of reel number, B2830, flight number, 690504." Cost of tabulation is $45.00 per mission. When ordering magnetic tape, specify one of the following, along with reel number in far left column: (A) 7 Channel; BCD; 200, 556, 800 BPI; or (B) 9 Channel; EBCDIC; 800 BPI.

Table 4-17. Island, Discoverer, Air Force WB-47, Navy WC-121, RFF DC-6 39C, RFF DC-6 40C, and RFF DC-4 82E Radar Data inventory

Order by reel No. in this column *	Type of radar	Data acquisition unit	Date and time of first frame		Date and time of last frame		Duplication cost **		Availability date for distribution
			Calendar Date, 1969	Hr: Min	Calendar Date, 1969	Hr: Min	Registered	Non-registered	
				(Local)		(Local)			
1	AN/MPS-34	Island radar	May 3	0100	May 6	1540	$20.00	$ 9.00	2/8/71
2	"	"	6	1825	9	2318	per reel	per reel	"
3	"	"	9	2330	13	0000	"	"	"
4	"	"	13	0013	13	2007	"	"	"
5	"	"	13	2203	15	1940	"	"	"
6	"	"	15	2000	23	0116	"	"	"
7	"	"	23	0245	23	0518	"	"	"
8	"	"	24	0705	24	2207	"	"	"
9	"	"	25	0000	26	0108	"	"	"
10	"	"	26	0309	26	2210	"	"	"
11	"	"	26	2330	28	1450	"	"	"
12	"	"	29	0100	30	1405	"	"	"
13	"	"	30	1450	31	1104	"	"	"
14	"	"	31	1240	June 1	1510	"	"	"
15	"	"	June 1	1530	2	0300	"	"	"
16	"	"	2	0405	2	1745	"	"	"
17	"	"	2	2112	3	0450	"	"	"
18	"	"	3	0705	3	1618	"	"	"
19	"	"	3	1730	4	0350	"	"	"
20	"	"	4	0525	4	2035	"	"	"
21	"	"	4	2115	6	1048	"	"	"
22	"	"	6	1120	7	0020	"	"	"
23	"	"	7	0155	7	1548	"	"	"
24	"	"	7	1725	8	1047	"	"	"
25	"	"	8	1123	9	0712	"	"	"

Table 4-17. Island, _Discoverer_, Air Force WB-47, Navy WC-121, RFF DC-6 39C, RFF DC-6 40C, and RFF DC-4 82E Radar Data inventory (continued)

Order by reel No. in this column *	Type of radar	Data acquisition unit	Date and time of first frame			Date and time of last frame			Duplication cost **		Availability date for distribution
			Calendar Date, 1969		Hr: Min	Calendar Date, 1969		Hr: Min	Registered	Non-registered	
26	AN/MPS-34	Island radar	June	9	(Local) 0830	June	10	(Local) 0500	$20.00 per reel	$ 9.00 per reel	2/8/71
27	"	"		10	0637		10	1535	"	"	"
28	"	"		10	1550		19	0651	"	"	"
29	"	"		19	0720		20	1407	"	"	"
30	"	"		20	1430		21	0520	"	"	"
31	"	"		21	0610		21	2225	"	"	"
32	"	"		21	2358		23	1237	"	"	"
33	"	"		23	1255		25	0825	"	"	"
34	"	"		25	0844		26	0920	"	"	"
35	"	"		26	1008		27	1425	"	"	"
36	"	"		27	1435		28	0855	"	"	"
37	"	"		28	0915		29	0800	"	"	"
38	"	"		29	0815		29	2135	"	"	"
39	"	"		29	2203	July	1	0008	"	"	"
40	"	"	July	1	0026		1	2030	"	"	"
41	"	"		8	1100		9	1700	"	"	"
42	"	"		9	1724		10	1000	"	"	"
43	"	"		10	1215		11	1440	"	"	"
44	"	"		12	0002		12	2305	"	"	"
45	"	"		12	2319		13	1257	"	"	"
46	"	"		13	2242		14	1005	"	"	"
47	"	"		15	0005		16	0723	"	"	"
48	"	"		16	1735		17	1808	"	"	"
49	"	"		17	1820		18	1257	"	"	"
50	"	"		18	1315		19	0555	"	"	"

Table 4-17. Island, <u>Discoverer</u>, Air Force WB-47, Navy WC-121, RFF DC-6 39C RFF DC-6 40C, and RFF DC-4 82E Radar Data inventory (continued)

Order by reel No. in this column *	Type of radar	Data acquisition unit	Date and time of first frame		Date and time of last frame		Duplication cost **		Availability date for distribution
			Calendar Date, 1969	Hr: Min	Calendar Date, 1969	Hr: Min	Registered	Non-registered	
				(Local)		(Local)			
51	AN/MPS-34	Island radar	July 19	0645	July 20	1800	$20.00 per reel	$ 9.00 per reel	2/8/71
52	"	"	20	1825	21	2204	"	"	"
53	"	"	21	2235	22	2155	"	"	"
54	"	"	22	2215	24	0900	"	"	"
55	"	"	24	0918	25	1455	"	"	"
56	"	"	25	1527	26	0704	"	"	"
57	"	"	26	0730	26	2255	"	"	"
58	"	"	26	2334	27	1159	"	"	"
				(GMT)		(GMT)			
59	Selenia	<u>Discoverer</u>	May 24	0000	May 27	2154	"	"	"
60	"	"	27	2200	29	1101	"	"	"
61	"	"	29	1630	June 1	1625	"	"	"
62	"	"	June 1	1645	4	2300	"	"	"
63	"	"	4	2309	20	2315	"	"	"
64	"	"	20	2320	24	0542	"	"	"
65	"	"	25	2143	27	1557	"	"	"
66	"	"	27	1557	29	0357	"	"	"
67	"	"	29	0409	July 2	0433	"	"	"
68	"	"	July 2	0435	13	1257	"	"	"
69	"	"	13	0303	16	0105	"	"	"
70	"	"	16	0114	17	1415	"	"	"
71	"	"	17	1417	20	1643	"	"	"
72	"	"	20	1651	23	1449	"	"	"
73	"	"	23	1450	25	1616	"	"	"

Table 4-17. Island, Discoverer, Air Force WB-47, Navy WC-121, RFF DC-6 39C RFF DC-6 40C, and RFF DC-4 82E Radar Data inventory (continued)

Order by reel No. in this column *	Type of radar	Data acquisition unit	Date and time of first frame		Date and time of last frame		Duplication cost **		Availability date for distribution
			Calendar Date, 1969	Hr: Min	Calendar Date, 1969	Hr: Min	Registered	Non-registered	
				(GMT)		(GMT)			
74	Selenia	Discoverer	July 25	1650	July 27	1716	$20.00 per reel	$ 9.00 per reel	2/8/71
75	"	"	27	1722	28	2049			"
84	AN/APS-64	AF WB-47	May 3	1411	May 3	1813	"	"	"
76	"	"	4	1146	4	1637	"	"	"
77	"	"	5	1149	5	1726	"	"	"
78	"	"	6	1105	6	1359	"	"	"
79	"	"	7	1205	7	1741	"	"	"
80	"	"	9	1320	9	1620	"	"	"
81	"	"	11	1159	11	1623	"	"	"
82	"	"	13	1600	13	2103	"	"	"
83	"	"	14	1155	14	1730	"	"	"
85	"	"	24	0550	24	0940	"	"	"
86	"	"	25	1212	25	1620	"	"	"
87	"	"	27	1240	27	1635	"	"	"
88	"	"	28	1315	28	1620	"	"	"
89	"	"	30	1025	30	1735	"	"	"
90	"	"	31	1220	31	1731	"	"	"
91	"	"	June 1	1230	June 1	1640	"	"	"
92	"	"	2	1150	2	1625	"	"	"
93	"	"	3	1135	3	1625	"	"	"
94	"	"	4	1150	4	1725	"	"	"
95	"	"	6	1239	6	1630	"	"	"

Table 4-17. Island, Discoverer, Air Force WB-47, Navy WC-121, RFF DC-6 39C, RFF DC-6 40C, and RFF DC-4 82E Radar Data inventory (continued)

Order by reel No. in this column *	Type of radar	Data acquisition unit	Date and time of first frame			Date and time of last frame			Duplication cost **		Availability date for distribution
			Calendar Date, 1969		Hr: Min	Calendar Date, 1969		Hr: Min	Registered	Non-registered	
					(GMT)			(GMT)			
96	AN/APS-64	AF WB-47	June	7	1200	June	7	1530	$20.00 per reel	$ 9.00 per reel	2/8/71
97	"	"		9	1140		9	1740	"	"	"
98	"	"		21	1425		21	1720	"	"	"
99	"	"		22	1220		22	1612	"	"	"
100	"	"		23	1305		23	1635	"	"	"
102	"	"		24	2305		24	0340	"	"	"
101	"	"		25	1200		25	1755	"	"	"
103	"	"		26	1255		26	1820	"	"	"
104	"	"		28	1210		28	1740	"	"	"
105	"	"		29	1240		29	1630	"	"	"
106	"	"		30	1140		30	1720	"	"	"
107	"	"	July	1	1135	July	1	1735	"	"	"
109	"	"		13	1313		13	1708	"	"	"
111	"	"		15	1358		15	1710	"	"	"
112	"	"		19	1220		19	1829	"	"	"
113	"	"		20	1106		20	1448	"	"	"
114	"	"		23	1215		23	1740	"	"	"
108	"	"		26	1306		26	1724	"	"	"
115	"	"		28	1250		28	1527	"	"	"
117	AN/APS-20E	Navy VW-4 121	July	14	1550	July	14	1900	"	"	"
116	"	"		19	1450		26	2035	"	"	"
118	RDR-1	RFF DC-6 40C	May	4	1102	May	4	1705	"	"	"
119	"	"		4	1705		4	2150	"	"	"

Table 4-17. Island, Discoverer, Air Force WB-47, Navy WC-121, RFF DC-6 39C, RFF DC-6 40C, and RFF DC-4 82E Radar Data inventory (continued)

Order by reel No. in this column *	Type of radar	Data acquisition unit	Date and time of first frame		Date and time of last frame		Duplication cost **		Availability date for distribution
			Calendar Date, 1969	Hr: Min	Calendar Date, 1969	Hr: Min	Registered	Non-registered	
				(GMT)		(GMT)			
120	APS-42	RFF DC-4 82E	May 4	1043	May 4	1335	$20.00 per reel	$ 9.00 per reel	2/8/71
121	"	"	4	1403	4	1701	"	"	"
122	"	"	4	1701	4	1945	"	"	"
123	"	"	4	2017	4	2147	"	"	"
124	WP-101	RFF DC-6 40C	May 9	1418	9	1943	"	"	"
125	RDR-1	"	9	1418	9	1943	"	"	"
126	APS-20	"	9	1500	9	1752	"	"	"
127	APS-42	RFF DC-4 82E	9	1610	9	1942	"	"	"
128	APS-20	RFF DC-6 40C	11	1736	11	2004	"	"	"
129	RDR-1	"	11	1030	11	1743	"	"	"
130	"	"	11	1743	11	2113	"	"	"
131	APS-42	RFF DC-4 82E	11	1030	11	2015	"	"	"
132	"	"	11	2015	11	2115	"	"	"
133	WP-101	RFF DC-6 39C	12	1154	12	1805	"	"	"
134	"	"	12	1805	12	2125	"	"	"
135	RDR-1	"	12	1154	12	1805	"	"	"
136	"	"	12	1805	12	2125	"	"	"

Table 4-17. Island, Discoverer, Air Force WB-47, Navy WC-121, RFF DC-6 39C, RFF DC-6 40C, and RFF DC-4 82E Radar Data inventory (continued)

Order by reel No. in this column *	Type of radar	Data acquisition unit	Date and time of first frame			Date and time of last frame			Duplication cost **		Availability date for distribution
			Calendar Date, 1969		Hr: Min	Calendar Date, 1969		Hr: Min	Registered	Non-registered	
137	RDR-1	RFF DC-6 40C	May	12	(GMT) 1141	May	12	(GMT) 1839	$20.00 per reel	$ 9.00 per reel	2/8/71
138	"	"		12	1845		12	2037	"	"	"
139	WP-101	"		26	1109		26	1135	"	"	"
140	"	"		26	1156		26	1600	"	"	"
141	"	"		26	1722		26	2105	"	"	"
142	RDR-1	"		26	1109		26	1943	"	"	"
143	"	"		26	1945		26	2214	"	"	"
144	APS-42	RFF DC-4 82E		26	1106		26	2036	"	"	"
145	"	"		26	2036		26	2118	"	"	"
146	WP-101	RFF DC-6 40C		27	1237		27	2105	"	"	"
147	RDR-1	"		27	1108		27	1844	"	"	"
148	"	"		27	1844		27	2121	"	"	"
149	APS-42	RFF DC-4 82E		27	1103		27	1312	"	"	"
150	WP-101	RFF DC-6 40C	June	1	1109	June	1	1815	"	"	"
151	"	"		1	1843		1	2147	"	"	"
152	"	"		2	1132		2	1840	"	"	"
153	"	"		2	1840		2	2143	"	"	"
154	"	"		3	1106		3	1824	"	"	"
155	"	"		3	1841		3	2114	"	"	"

Table 4-17. Island, Discoverer, Air Force WB-47, Navy WC-121, RFF DC-6 39C, RFF DC-6 40C, and RFF DC-4 82E Radar Data inventory (continued)

Order by reel No. in this column *	Type of radar	Data acquisition unit	Date and time of first frame			Date and time of last frame			Duplication cost **		Availability date for distribution
			Calendar Date, 1969		Hr: Min	Calendar Date, 1969		Hr: Min	Registered	Non-registered	
156	APS-42	RFF DC-4 82E	June	3	(GMT) 1422	June	3	(GMT) 2131	$20.00 per reel	$ 9.00 per reel	2/8/71
157	WP-101	RFF DC-6 40C		7	1031		7	1745	"	"	"
158	"	"		7	1752		7	2057	"	"	"
159	APS-20	"		7	1531		7	2045	"	"	"
160	APS-42	RFF DC-4 82E		7	1017		7	2150	"	"	"
161	WP-101	RFF DC-6 40C		9	1029		9	1728	"	"	"
162	"	"		9	1728		9	2102	"	"	"
163	APS-20	"		9	1445		9	1940	"	"	"
164	APS-42	RFF DC-4 82E		9	1126		9	1932	"	"	"
165	WP-101	RFF DC-6 40C		22	1047		22	1749	"	"	"
166	"	"		22	1749		22	2123	"	"	"
167	RDR-1	"		22	1100		22	1749	"	"	"
168	"	"		22	1753		22	2123	"	"	"
169	APS-42	RFF DC-4 82E		22	1018		22	1440	"	"	"

Table 4-17. Island, Discoverer, Air Force WB-47, Navy WC-121, RFF DC-6 39C, RFF DC-6 40C, and RFF DC-4 82E Radar Data inventory (continued)

Order by reel No. in this column *	Type of radar	Data acquisition unit	Date and time of first frame		Date and time of last frame		Duplication cost **		Availability date for distribution
			Calendar Date, 1969	Hr: Min	Calendar Date, 1969	Hr: Min	Registered	Non-registered	
				(GMT)		(GMT)			
170	WP-101	RFF DC-6 40C	June 23	1215	June 23	1925	$20.00 per reel	$ 9.00 per reel	2/8/71
171	"	"	23	1935	23	2305	"	"	"
172	RDR-1	"	23	1215	23	1930	"	"	"
173	"	"	23	1935	23	2310	"	"	"
174	APS-42	RFF DC-4 82E	23	1840	24	0255	"	"	"
175	RDR-1	RFF DC-6 40C	25	2246	26	0130	"	"	"
176	"	"	26	0409	26	0942	"	"	"
177	APS-42	RFF DC-4 82E	25	2236	26	0937	"	"	"
178	"	"	28	1326	28	2008	"	"	"
179	RDR-1	RFF DC-6 40C	29	1012	29	1736	"	"	"
180	"	"	29	1736	29	2114	"	"	"
182	APS-42	RFF DC-4 82E	29	1025	29	2114	"	"	"
183	RDR-1	RFF DC-6 40C	30	1110	30	1838	"	"	"
184	"	"	30	1738	30	2116	"	"	"
185	APS-42	RFF DC-4 82E	30	1108	30	1304	"	"	"
186	"	"	July 2	1237	July 2	2058	"	"	"

Table 4-17. Island, Discoverer, Air Force WB-47, Navy WC-121, RFF DC-6 39C, RFF DC-6 40C, and RFF DC-4 82E Radar Data inventory (continued)

Order by reel No. in this column *	Type of radar	Data acquisition unit	Date and time of first frame			Date and time of last frame			Duplication cost **		Availability date for distribution
			Calendar Date, 1969		Hr: Min	Calendar Date, 1969		Hr: Min	Registered	Non-registered	
					(GMT)			(GMT)			
187	APS-20	RFF DC-6 39C	July	11	1438	July	11	2112	$20.00 per reel	$ 9.00 per reel	2/8/71
188	WP-101	"		11	1433		11	1719			"
189	APS-20	RFF DC-6 40C		11	1554		11	2004	"	"	"
190	WP-101	"		11	1121		11	1816	"	"	"
191	"	"		11	1818		11	2208	"	"	"
192	RDR-1	"		11	1334		11	1817	"	"	"
193	"	"		11	1818		11	2210	"	"	"
194	RDR-1	RFF DC-6 39C		13	1355		13	2000	"	"	"
195	"	"		13	2001		13	2225	'	"	"
196	APS-20	RFF DC-6 40C		13	1431		13	2223	"	"	"
197	WP-101	"		13	1230		13	1933	"	"	"
198	"	"		13	1934		13	2226	"	"	"
199	RDR-1	"		13	1232		13	2034	"	"	"
200	"	"		13	2035		13	2226	"	"	"
201	APS-42	RFF DC-4 82E		13	1225		13	1507	"	"	"
202	APS-20	RFF DC-6 39C		14	1430		14	2345	"	"	"
203	RDR-1	"		14	1335		14	2021	"	"	"
204	"	"		14	2023		14	2345	"	"	"
205	APS-20	RFF DC-6 40C		14	2120		14	2345	"	"	"
206	WP-101	"		14	1448		14	2105	"	"	"
207	"	"		14	2106		14	2353	"	"	"
208	RDR-1	"		14	1339		14	2104	"	"	"
209	"	"		14	2104		14	2353	"	"	"

Table 4-17. Island, Discoverer, Air Force WB-47, Navy WC-121, RFF DC-6 39C, RFF DC-6 40C, and RFF DC-4 82E Radar Data inventory (continued)

Order by reel No. in this column *	Type of radar	Data acquisition unit	Date and time of first frame		Date and time of last frame		Duplication cost **		Availability date for distribution
			Calendar Date, 1969	Hr: Min	Calendar Date, 1969	Hr: Min	Registered	Non-registered	
210	APS-42	RFF DC-4 82E	July 15	(GMT) 1210	July 15	(GMT) 1702	$20.00 per reel	$ 9.00 per reel	2/8/71
211	APS-20	RFF DC-6 39C	18	1145	18	2013	"	"	"
212	RDR-1	"	18	1145	18	1845	"	"	"
213	"	"	18	1546	18	2013	"	"	"
214	APS-20	RFF DC-6 40C	18	1136	18	1921	"	"	"
215	"	"	18	2002	18	2128	"	"	"
216	WP-101	"	18	1323	18	1352	"	"	"
217	"	"	18	1518	18	2128	"	"	"
218	RDR-1	"	18	1116	18	1522	"	"	"
219	"	"	18	1523	18	2128	"	"	"
220	APS-42	RFF DC-4 82E	18	1114	18	2053	"	"	"
221	APS-20	RFF DC-6 40C	20	1636	20	2218	"	"	"
222	WP-101	"	20	1521	20	2223	"	"	"
223	RDR-1	"	20	1520	20	2223	"	"	"
224	APS-42	RFF DC-4 82E	21	1309	21	1743	"	"	"
225	APS-20	RFF DC-6 40C	23	1502	23	2223	"	"	"
226	WP-101	"	23	1240	23	1935	"	"	"
227	"	"	23	1937	23	2223	"	"	"
228	"	"	23	1240	23	1932	"	"	"
229	"	"	23	1933	23	2223	"	"	"
230	APS-42	RFF DC-4 82E	23	1240	23	2129	"	"	"

Table 4-17. Island, Discoverer, Air Force WB-47, Navy WC-121, RFF DC-6 39C, RFF DC-6 40C, and RFF DC-4 82E Radar Data inventory (continued)

Order by reel No. in this column *	Type of radar	Data acquisition unit	Date and time of first frame		Date and time of last frame		Duplication cost **		Availability date for distribution
			Calendar Date, 1969	Hr: Min	Calendar Date, 1969	Hr: Min	Registered	Non-registered	
				(GMT)		(GMT)			
231	RDR-1	RFF DC-6 39C	July 25	1016	July 25	1720	$20.00	$ 9.00	2/8/71
232	"	"	25	1720	25	2154	per reel	per reel	"
233	"	"	26	1324	26	2006	"	"	"
234	"	"	26	2006	26	0017	"	"	"
235	APS-20	RFF DC-6 40C	26	1028	26	2000	"	"	"
236	WP-101	"	26	1011	26	1706	"	"	"
237	"	"	26	1707	26	2003	"	"	"
238	RDR-1	"	26	1012	26	1704	"	"	"
239	"	"	26	1705	26	2000	"	"	"
240	APS-42	RFF DC-4 82E	26	0916	26	1615	"	"	"
241	WP-101	RFF DC-6 39C	28	1435	28	2143	"	"	"
242	"	"	28	2144	28	2351	"	"	"
243	RDR-1	"	28	1435	28	2142	"	"	"
244	"	"	28	2143	28	2351	"	"	"

*Radar film will be sent as a positive copy.

**When ordering radar film, specify registered or nonregistered copy. Allow 3 weeks for delivery of registered and 2 weeks for delivery of nonregistered film after receipt of request.

Table 4-18. RFF Aircraft Cloud Photograph Data inventory

Order by designation in this column		Film type	Aircraft	Type of camera	Contents of reel: Date and time of first frame: Calendar Date, 1969		Hr: Min (GMT)	Date and time of last frame: Calendar Date, 1969		Hr: Min (GMT)	RFF flight No.	Distribution cost *	Availability date for distribution
504	AF	16-mm 400-ft reel, color	RFF DC-6 39C	Nose camera	May	4	1440	May	4	2154	690504	$108.00 per 400-ft reel	1/24/71
505	AF	"	"	"		5	1446		5	2100	690505	"	"
510	AF	"	"	"		10	0941		10	1751	690610	"	"
511	AF	"	"	"		11	1346		11	2134	690511	"	"
512	AF	"	"	"		12	1129		12	2029	690512	"	"
514	AF	"	"	"		14	1200		14	1950	690514	"	"
517	AF	"	"	"		17	1400		17	1910	690517	"	"
522	AF	"	"	"		22	1730		22	2335	690522	"	"
524	AF	"	"	"		24	1835		24	2205	690524	"	"
526	AF	"	"	"		26	1437		26	2205	690526	"	"
527	AF	"	"	"		27	1310		27	2200	690527	"	"
601	AF	"	"	"	June	1	1255	June	1	2054	690601	"	"
603	AF	"	"	"		3	1300		3	1929	690603	"	"
607	AF	"	"	"		7	1130		7	2023	690607	"	"
609	AF	"	"	"		9	1130		9	2015	690609	"	"
621	AF	"	"	"		21	1701		21	2153	690621	"	"
622	AF	"	"	"		22	1130		22	2040	690622	"	"
628	AF	"	"	"		28	1316		28	2034	690628	"	"
629	AF	"	"	"		29	1320		29	2013	690629	"	"
630	AF	"	"	"		30	1358		30	2220	690630	"	"
702	AF	"	"	"	July	2	1222	July	2	2029	690702	"	"
713	AF	"	"	"		13	1338		13	2235	690713	"	"
714	AF	"	"	"		14	1430		14	2230	690714	"	"
718	AF	"	"	"		18	1235		18	2018	690718	"	"
720	AF	"	"	"		20	1457		20	2152	690720	"	"
723	AF	"	"	"		23	1229		23	2118	690723	"	"
726	AF	"	"	"		26	1258		26	2212	690726	"	"
728	AF	"	"	"		28	1418		28	2230	690728	"	"

Table 4-18. RFF Aircraft Cloud Photograph Data inventory (continued)

Order by designation in this column	Film type	Aircraft	Type of camera	Contents of reel: Date and time of first frame: Calendar Date, 1969	Hr: Min (GMT)	Date and time of last frame: Calendar Date, 1969	Hr: Min (GMT)	RFF flight No.	Distribution cost *	Availability date for distribution
504 AR	35-mm 800-ft reel, black & white	RFF DC-6 39C	Right side camera	May 4	1440	May 10	1751	690504 690505 690510	$88.00 per 800-ft reel	1/24/71
511 AR	"	"	"	11	1346	12	2132	690511 690512	"	"
514 AR	"	"	"	14	1200	17	1910	690514 690517	"	"
522 AR	"	"	"	22	1730	26	2205	690522 690524 690526	"	"
527 AR	"	"	"	27	1310	June 1	2220	690527 690529 690601	"	"
603 AR	"	"	"	June 3	1300	7	2220	690603 690607	"	"
609 AR	"	"	"	9	0955	9	2153	690609	"	"
621 AR	"	"	"	21	1701	22	2211	690621 690622	"	"
628 AR	"	"	"	28	1316	30	2159	690628 690629 690630	"	"
702 AR	"	"	"	July 2	1222	July 2	2029	690702	"	"
713 AR	"	"	"	13	1201	14	2230	690713 690714	"	"
718 AR	"	"	"	18	1108	20	2152	690718 690720	"	"
723 AR	"	"	"	23	1227	25	2037	690723 690725	"	"
726 AR	"	"	"	26	1257	28	2219	690726 690728	"	"

Table 4-18. RFF Aircraft Cloud Photograph Data inventory (continued)

Order by designation in this column	Film type	Aircraft	Type of camera	Contents of reel: Date and time of first frame: Calendar Date, 1969	Hr: Min (GMT)	Date and time of last frame: Calendar Date, 1969	Hr: Min (GMT)	RFF flight No.	Distribution cost *	Availability date for distribution
504 AL	35-mm 800-ft reel, black white	RFF DC-6 39C	Left side camera	May 4	1440	May 10	1751	690504 690605 690510	$88.00 per 800-ft reel	1/24/71
511 AL	"	"	"	11	1346	12	2132	690511 690512	"	"
514 AL	"	"	"	14	1200	17	1910	690514 690517	"	"
522 AL	"	"	"	22	1730	26	2205	690522 690524 690526	"	"
527 AL	"	"	"	27	1310	June 1	2220	690527 690529 690601	"	"
603 AL	"	"	"	June 3	1300	7	2220	690603 690607	"	"
609 AL	"	"	"	9	0955	9	2153	690609	"	"
621 AL	"	"	"	21	1701	22	2211	690621 690622	"	"
628 AL	"	"	"	28	1316	30	2159	690628 690629 690630	"	"
702 AL	"	"	"	July 2	1222	July 2	2029	690702	"	"
713 AL	"	"	"	13	1201	14	2215	690713	"	"
718 AL	"	"	"	18	1108	20	2152	690718 690720	"	"
723 AL	"	"	"	23	1227	25	2021	690723 690725	"	"
726 AL	"	"	"	26	1257	28	2230	690726 690728	"	"

Table 4-18. RFF Aircraft Cloud Photograph Data inventory (continued)

Order by designation in this column	Film type	Aircraft	Type of camera	Contents of reel: Date and time of first frame: Calendar Date, 1969	Hr: Min (GMT)	Date and time of last frame: Calendar Date, 1969	Hr: Min (GMT)	RFF flight No.	Distribution cost *	Availability date for distribution
504 BF	16-mm 400-ft reel, color	RFF DC-6 40C	Nose camera	May 4	1024	May 4	1541	690504	$108.00 per 400-ft reel	1/24/71
509 BF	"	"	"	9	1357	9	2001	690509	"	"
511 BF	"	"	"	11	1020	11	1730	690511	"	"
512 BF	"	"	"	12	1124	12	1951	690512	"	"
526 BF	"	"	"	26	1055	26	1950	690526	"	"
527 BF	"	"	"	27	1050	27	1948	690527	"	"
601 BF	"	"	"	June 1	1045	June 1	1958	690601	"	"
602 BF	"	"	"	2	1050	2	1948	690602	"	"
603 BF	"	"	"	3	1055	3	2011	690603	"	"
607 BF	"	"	"	7	1020	7	1958	690607	"	"
609 BF	"	"	"	9	1020	9	1823	690609	"	"
622 BF	"	"	"	22	1026	22	1915	690622	"	"
629 BF	"	"	"	29	1000	29	1855	690629	"	"
630 BF	"	"	"	30	1100	30	1930	690630	"	"
713 BF	"	"	"	July 13	1205	July 13	2140	690713	"	"
714 BF	"	"	"	14	1314	14	1802	690714	"	"
718 BF	"	"	"	18	1135	18	1305	690718	"	"
720 BF	"	"	"	20	1513	20	2159	690720	"	"
723 BF	"	"	"	23	1230	23	1351	690723	"	"
726 BF	"	"	"	26	1012	26	1728	690726	"	"

Table 4-18. RFF Aircraft Cloud Photograph Data inventory (continued)

Order by designation in this column	Film type	Aircraft	Type of camera	Contents of reel: Date and time of first frame: Calendar Date, 1969	Hr: Min (GMT)	Date and time of last frame: Calendar Date, 1969	Hr:Min (GMT)	RFF flight No.	Distribution cost *	Availability date for distribution
504 BR	35-mm 800-ft reel, black & white	RFF DC-6 40C	Right side camera	May 4	1024	May 9	1959	690504 690509	$88.00 per 800-ft reel	1/24/71
511 BR	"	"	"	11	1020	12	2125	690511 690512	"	"
526 BR	"	"	"	26	1055	27	2133	690526 690527	"	"
601 BR	"	"	"	June 1	1045	June 2	2148	690601 690602	"	"
603 BR	"	"	"	3	1055	7	2113	690603 690907	"	"
609 BR	"	"	"	9	1015	9	2110	690909	"	"
622 BR	"	"	"	22	1025	29	2108	690622 690629		
630 BR	"	"	"	30	1100	30	2125	690630		
711 BR	"	"	"	July 11	1502	July 11	2116	690711	"	"
713 BR	"	"	"	13	1200	14	2230	690713 690714	"	"
718 BR	"	"	"	18	1201	20	2220	690718 690720	"	"
723 BR	"	"	"	23	1230	26	2007	690723 690726	"	"

Table 4-18. RFF Aircraft Cloud Photograph Data inventory (continued)

Order by designation in this column	Film type	Aircraft	Type of camera	Contents of reel: Date and time of first frame: Calendar Date, 1969	Contents of reel: Date and time of first frame: Hr: Min (GMT)	Contents of reel: Date and time of last frame: Calendar Date, 1969	Contents of reel: Date and time of last frame: Hr: Min (GMT)	RFF flight No.	Distribution cost *	Availability date for distribution
504 BL	35-mm 800-ft reel, black white	RFF DC-6 40C	Left side camera	May 4	1024	May 9	1959	690504 690609	$88.00 per 800-ft reel	1/24/71
511 BL	"	"	"	11	1020	12	2125	690511 690512	"	"
526 BL	"	"	"	26	1055	27	2133	690526 690527	"	"
601 BL	"	"	"	June 1	1045	June 2	2148	690601 690602	"	"
603 BL	"	"	"	3	1055	7	2113	690603 690607	"	"
609 BL	"	"	"	9	1015	9	2110	690609	"	"
622 BL	"	"	"	22	1025	29	2000	690622 690629	"	"
630 BL	"	"	"	30	1100	30	2125	690630	"	"
711 BL	"	"	"	July 11	1334	July 11	0518	690711	"	"
713 BL	"	"	"	13	1200	14	2209	690713 690714	"	"
718 BL	"	"	"	18	1100	20	2227	690720	"	"
723 BL	"	"	"	23	1230	26	2007	690723 690726	"	"

*Allow 4 to 6 weeks for delivery after receipt of request.

Table 4-19. Navy and Air Force RECCO Data and Air Force WC-130 Dropsonde Data inventory

Order by designation in this column	Archived form of data *	Name of aircraft	Contents	Duplication cost	Availability date for distribution
B3405	Magnetic tape	Navy WC-121, AF WB-47, AF RB-57, and AF WC-130	All RECCO Observations by the Navy and Air Force aircraft during the four BOMEX Observation Periods; one file for each aircraft on tape, with all RECCO Observations for that aircraft in chronological order	$60.00 (includes cost cost of tape)	2/1/71
Listing of WC-121 file from tape B3405	Computer printout	Navy WC-121	Tabulation of all RECCO Observation by the WC-121 during BOMEX	$30.00	2/1/71
Listing of WB-47 file from tape B3405	Computer printout	Air Force WB-47	Tabulation of all RECCO Observations by the WB-47 during BOMEX	$30.00	2/1/71
Listing of RB-57 file from tape B3405	Computer printout	Air Force RB-57	Tabulation of all RECCO Observations by the RB-57 during BOMEX	$30.00	2/1/71
Listing of WC-130 file from tape B3405	Computer printout	Air Force WC-130	Tabulation of all WC-130 data for all four BOMEX Observation Periods	$30.00	2/1/71

Table 4-19. Navy and Air Force RECCO Data and Air Force WC-130 Dropsonde Data inventory (continued)

Order by designation in this column	Archived form of data *	Name of aircraft	Contents	Duplication cost	Availability date for distribution
B9622	Magnetic tape	Air Force WC-130	Tabulation of all WC-130 Dropsonde data for all four BOMEX Observation Periods	$60.00 (includes cost of tapes)	2/1/71
Listing of Dropsonde File from tape B9622	Computer printout	Air Force WC-130	Tabulation of Dropsonde File from magnetic tape B9622	$15.00	2/1/71

*When ordering magnetic tape, specify (A) 7 Channel; BCD; 200, 556, or 800 BPI; or (B) 9 Channel; EBCDIC; 800 BPI. Tape B9622 contains five other files in addition to the Dropsonde Data.

Table 4-20. Island Rawinsonde Data inventory

Order by designation in this column	Date: Calendar date	Date: Julian day	BOMEX Observation Period	Launch times (GMT)	Duplication cost **	Availability date for distribution
IR # 1	May 2	122	Period I	1100	$2.50 per observation	2/1/71
2	3	123	"	1100		"
3	4	124	"	1100		"
4	5	125	"	1102	"	"
5	6	126	"	0900	"	"
6	7	127	"	0925	"	"
7	8	128	"	1100	"	"
8	9	129	"	1129	"	"
9	10	130	"	1100	"	"
10	11	131	"	1100	"	"
11	12	132	"	0140	"	"
12	12	133	"	1930	"	"
13	13	133	"	0125	"	"
14	13	134	"	1935	"	"
15	14	134	"	0145	"	"
16	14	135	"	1935	"	"
17	(Missing)		"		"	"
18	15	135	"	1925	'	"
19	16	136	"	0115	"	"
20	16	136	"	1759	"	"
21	17	137	"	0115	"	"
22	17	137	"	1940	"	"
23	18	138	"	0130	"	"
28	20*	140	"	1940	"	"
50	June 1	152	Period II	0125	"	"
51	1	152	"	1315	"	"
52	2	153	"	0155	"	"
53	2	153	"	1325	"	"
54	3	154	"	0150	"	"
55	3	154	"	1319	"	"
56	4	155	"	0150	"	"
57	4	155	"	1326	"	"

Table 4-20. Island Rawinsonde Data inventory
(continued)

Order by designation in this column	Date: Calendar date	Date: Julian day	BOMEX Observation Period	Launch times (GMT)	Duplication cost **	Availability date for distribution
IR # 58	June 5	156	Period II	0147	$2.50 per observation	2/1/71
59	6	156	"	1323		"
60	6	157	"	0130		"
61	6	157	"	1317	"	"
62	7	158	"	0145	"	"
63	7	158	"	1315	"	"
64	8	159	"	0115	"	"
65	8	159	"	1319	"	"
66	9	160	"	0120	"	"
67	9	160	"	1317	"	"
68	10	161	"	0120	"	"
69	10	161	"	1343	"	"
70	11	162	"	0145	"	"
71	11	162	"	1317	"	"
72	12	163	"	0229	"	"
73	12	163	"	1335	"	"
74	13	164	"	0240	"	"
75	14	165	"	1325	"	"
76	14	165	"	0147	"	"
77	15	166	"	1315	"	"
78	15	166	"	0140	"	"
79	16	167	"	1320	"	"
80	16	167	"	0120	"	"
81	16	167	"	1420	"	"
82	17	168	"	0123	"	"
83	17	168	"	1320	"	"
84	18	169	"	0115	"	"
85	18	169	"	1318	"	"
86	19	170	Period III	0117	"	"
87	19	170	"	1330	"	"
88	20	171	"	0135	"	"
89	20	171	"	1317	"	"

Table 4-20. Island Rawinsonde Data inventory
(continued)

Order by designation in this column	Date: Calendar date	Date: Julian day	BOMEX Observation Period	Launch times (GMT)	Duplication cost **	Availability date for distribution
IR # 90	June 21	172	Period III	0235	$2.50	2/1/71
91	21	172	"	1315	per	"
92	22	173	"	0115	observation	"
93	22	173	"	1315	"	"
94	23	174	"	0121	"	"
95	23	174	"	1315	"	"
96	24	175	"	0128	"	"
97	24	175	"	1315	"	"
98	25	176	"	0138	"	"
99	25	176	"	1324	"	"
100	26	177	"	0125	"	"
101	26	177	"	1330	"	"
102	27	178	"	0115	"	"
103	27	178	"	1315	"	"
104	28	179	"	0115	"	"
105	28	179	"	1315	"	"
106	29	180	"	0115	"	"
107	29	180	"	1315	"	"
108	30	181	"	0120	"	"
109	30	181	"	1315	"	"
110	July 1	182	"	0115	"	"
111	1	182	"	1315	"	"
112	2	183	"	0124	"	"
113	2	183	"	1315	"	"
114	3	184	"	0145	"	"
115	3	184	"	1315	"	"
116	4	185	"	0115	"	"
117	4	185	"	1315	"	"
118	5	186	"	0115	"	"
119	5	186	"	1315	"	"
120	6	187	"	0120	"	"
121	6	187	"	1305	"	"

Table 4-20. Island Rawinsonde Data inventory
(continued)

Order by designation in this column	Date: Calendar date	Date: Julian day	BOMEX Observation Period	Launch times (GMT)	Duplication cost **	Availability date for distribution
IR # 122	July 7	188	Period III	0120	$2.50	2/1/71
123	7	188	"	1318	per	"
124	8	189	"	0235	observation	"
125	8	189	"	1315	"	"
126	9	190	"	0115	"	"
127	9	190	"	1317	"	"
128	10	191	"	0115	"	"
129	10	191	"	1320	"	"
130	11	192	Period IV	0120	"	"
131	11	192	"	1317	"	"
132	12	193	"	0127	"	"
133	12	193	"	1317	"	"
134	13	194	"	0140	"	"
135	13	194	"	1315	"	"
136	14	195	"	0118	"	"
137	14	195	"	1315	"	"
138	15	196		0130	"	"
139	15	196	"	1328	"	"
140	16	197	"	0135	"	"
141	16	197	"	1315	"	"
142	17	198	"	0115	"	"
143	17	198	"	1320	"	"
144	18	199	"	0115	"	"
145	18	199	"	1320	"	"
146	19	200	"	0135	"	
147	19	200	"	1015	"	"
148	19	200	"	1315	"	"
149	19	200	"	1615	"	"
150	20	201	"	0135	"	"
151	20	201	"	1015	"	"
152	20	201	"	1316	"	"
153	20	201	"	1615	"	"

Table 4-20. Island Rawinsonde Data inventory
(continued)

Order by designation in this column	Date: Calendar date	Date: Julian day	BOMEX Observation Period	Launch times (GMT)	Duplication cost **	Availability date for distribution
IR # 154	July 21	202	Period IV	0115	$2.50	2/1/71
155	21	202	"	1100	per	"
156	21	202	"	1345	observation	"
157	21	202	"	1615	"	"
158	22	203	"	0115	"	"
159	22	203	"	1016	"	"
160	22	203	"	1321	"	"
161	22	203	"	1615	"	"
162	23	204	"	0115	"	"
163	23	204	"	1015	"	"
164	23	204	"	1315	"	"
165	23	204	"	1615	"	"
166	24	205	"	0125	"	"
167	24	205	"	1320	"	"
168	25	206	"	0116	"	"
169	25	206	"	1016	"	"
170	25	206	"	1315	"	"
171	25	206	"	1615	"	"
172	26	207	"	0115	"	"
173	26	207	"	1015	"	"
174	26	207	"	1315	"	"
175	26	207	"	1615	"	"
176	27	208	"	0135	"	"
177	27	208	"	1015	"	"
178	27	208	"	1315	"	"
179	27	208	"	1620	"	"
180	28	209	"	0121	"	"
181	28	209	"	1022	"	"
182	28	209	"	1405	"	"

* Observations were made from May 21 to May 31, 1969, but they have not yet been evaluated. When these data have been processed, they will be placed in the BOMEX Temporary Archive.

** Cost of duplication of all Island Rawinsonde Data is $400.00.

Table 4-21. ATS-3 Data inventory

Order by designation in this column		Date 1969 Calendar date	Julian day	Time of picture (GMT)	Duplication cost	Availability date for distribution
ATS	1	July 10	191	1530	Positive	2/1/71
"	2	"	"	2013	transparency	"
"	3	"	"	2038	$2.00 each.	"
"	4	July 11	192	1021	Print $1.50	"
"	5	"	"	1041	each	"
"	6	"	"	1240	"	"
"	7	"	"	1300	"	"
"	8	"	"	1610	"	"
"	9	"	"	1634	"	"
"	10	"	"	1700	"	"
"	11	"	"	1723	"	"
"	12	"	"	1850	"	"
"	13	"	"	1916	"	"
"	14	"	"	2230	"	"
"	15	July 12	193	0910	"	"
"	16	"	"	1009	"	"
"	17	"	"	1022	"	"
"	18	"	"	1040	"	"
"	19	"	"	1050	"	"
"	20	"	"	1125	"	"
"	21	"	"	1213	"	"
"	22	"	"	1239	"	"
"	23	"	"	1305	"	"
"	24	"	"	1330	"	"
"	25	"	"	1614	"	"
"	26	"	"	1639	"	"
"	27	"	"	1900	"	"

Table 4-21. ATS-3 Data inventory
(continued)

Order by designation in this column		Date 1969 Calendar date	Julian day	Time of picture (GMT)	Duplication cost	Availability date for distribution
ATS	28	July 13	194	1007	Positive transparency $2.00 each. Print $1.50 each	2/1/71
"	29	"	"	1034		"
"	30	"	"	1100		"
"	31	"	"	1142		"
"	32	"	"	1210		"
"	33	"	"	1247	"	"
"	34	"	"	1314	"	"
"	35	"	"	1344	"	"
"	36	"	"	1415	"	"
"	37	"	"	1440	"	"
"	38	"	"	1515	"	"
"	39	"	"	1534	"	"
"	40	"	"	1550	"	"
"	41	"	"	1755	"	"
"	42	"	"	1919	"	"
"	43	"	"	1944	"	"
"	44	July 14	195	1300	"	"
"	45	"	"	1435	"	"
"	46	"	"	1534	"	"
"	47	"	"	1610	"	"
"	48	"	"	1625	"	"
"	49	"	"	2040	"	"
"	50	July 15	196	1014	"	"
"	51	"	"	1037	"	"
"	52	"	"	1103	"	"
"	53	"	"	1153	"	"
"	54	"	"	1202	"	"
"	55	"	"	1223	"	"
"	56	"	"	1313	"	"
"	57	"	"	1331	"	"
"	58	"	"	1354	"	"
"	59	"	"	1422	"	"

Table 4-21. ATS-3 Data inventory
(continued)

Order by designation in this column		Date 1969 Calendar date	Date 1969 Julian day	Time of picture (GMT)	Duplication cost	Availability date for distribution
ATS	60	July 15	196	1446	Positive transparency $2.00 each. Print $1.50 each.	2/1/71
"	61	"	"	1551		"
"	62	"	"	1626		"
"	63	"	"	1700		"
"	64	"	"	1815		"
"	65	July 17	198	1425	"	"
"	66	"	"	1756	"	"
"	67	"	"	1834	"	"
"	68	"	"	1902	"	"
"	69	"	"	1925	"	"
"	70	"	"	1929	"	"
"	71	"	"	1951	"	"
"	72	"	"	2015	"	"
"	73	"	"	2040	"	"
"	74	July 18	199	1023	"	"
"	75	"	"	1100	"	"
"	76	"	"	1135	"	"
"	77	"	"	1210	"	"
"	78	"	"	1240	"	"
"	79	"	"	1312	"	"
"	80	"	"	1340	"	"
"	81	"	"	1402	"	"
"	82	"	"	1425	"	"
"	83	"	"	1428	"	"
"	84	"	"	1453	"	"
"	85	"	"	1519	"	"
"	86	"	"	1729	"	"
"	87	"	"	1751	"	"
"	88	"	"	1900	"	"
"	89	"	"	1923	"	"
"	90	"	"	1948	"	"

Table 4-21. ATS-3 Data inventory
(continued)

Order by designation in this column		Date 1969 Calendar date	Date 1969 Julian day	Time of picture (GMT)	Duplication cost	Availability date for distribution
ATS	91	July 19	200	1015	Positive	2/1/71
"	92	"	"	1035	transparency	"
"	93	"	"	1628	$2.00 each.	"
"	94	"	"	1643	Print $1.50	"
"	95	"	"	1812	each	"
"	96	"	"	1842	"	"
"	97	"	"	2022	"	"
"	98	July 20	201	1050	"	"
"	99	"	"	1218	"	"
"	100	"	"	1242	"	"
"	101	"	"	1306	"	"
"	102	"	"	1332	"	"
"	103	"	"	1358	"	"
"	104	"	"	1423	"	"
"	105	"	"	1450	"	"
"	106	"	"	1529	"	"
"	107	"	"	1608	"	"
"	108	"	"	1634	"	"
"	109	"	"	1701	"	"
"	110	"	"	1722	"	"
"	111	"	"	1748	"	"
"	112	"	"	1814	"	"
"	113	"	"	1840	"	"
"	114	"	"	1913	"	"
"	115	"	"	1940	"	"
"	116	July 21	202	1035	"	"
"	117	"	"	1105	"	"
"	118	"	"	1137	"	"
"	119	"	"	1200	"	"
"	120	"	"	1225	"	"
"	121	"	"	1250	"	"
"	122	"	"	1320	"	"
"	123	"	"	1354	"	"
"	124	"	"	1422	"	"
"	125	"	"	1512	"	"

Table 4-21. ATS-3 Data inventory
(continued)

Order by designation in this column		Date 1969 Calendar date	Date 1969 Julian day	Time of picture (GMT)	Duplication cost	Availability date for distribution
ATS	126	July 21	202	1537	Positive	2/1/71
"	127	"	"	1614	transparency	"
"	128	"	"	1643	$2.00 each.	"
"	129	"	"	1905	Print $1.50	"
"	130	"	"	2020	each.	"
"	131	July 22	203	1040	"	"
"	132	"	"	1100	"	"
"	133	"	"	1135	"	"
"	134	"	"	1154	"	"
"	135	"	"	1228	"	"
"	136	"	"	1246	"	"
"	137	"	"	1255	"	"
"	138	"	"	1315	"	"
"	139	"	"	1330	"	"
"	140	"	"	1337	"	"
"	141	"	"	1410	"	"
"	142	"	"	1417	"	"
"	143	"	"	1459	"	"
"	144	"	"	1518	"	"
"	145	"	"	1530	"	"
"	146	"	"	1542	"	"
"	147	"	"	1600	"	"
"	148	"	"	1649	"	"
"	149	"	"	1654	"	"
"	150	"	"	1810	"	"
"	151	"	"	1815	"	"
"	152	"	"	1835	"	"
"	153	"	"	1907	"	"
"	154	July 23	204	1006	"	"
"	155	"	"	1031	"	"
"	156	"	"	1055	"	"
"	157	"	"	1130	"	"
"	158	"	"	1407	"	"
"	159	"	"	1434	"	"
"	160	"	"	1505	"	"
"	161	"	"	1528	"	"
"	162	"	"	1627	"	"
"	163	"	"	1658	"	"
"	164	"	"	2030	"	"
"	165	July 24	205	1058	"	"
"	166	"	"	1116	"	"
"	167	"	"	1142	"	"
"	168	"	"	1158	"	"
"	169	"	"	1225	"	"
"	170	"	"	1250	"	"

Table 4-21. ATS-3 Data inventory
(continued)

Order by designation in this column		Date 1969 Calendar date	Julian day	Time of picture (GMT)	Duplication cost	Availability date for distribution
ATS	171	July 24	205	1315	Positive transparency $2.00 each. Print $1.50 each.	2/1/71
"	172	"	"	1536		"
"	173	"	"	1717		"
"	174	"	"	1812		"
"	175	"	"	1845		"
"	176	"	"	1906	"	"
"	177	"	"	1930	"	"
"	178	"	"	2000	"	"
"	179	"	"	2030	"	"
"	180	July 25	206	1121	"	"
"	181	"	"	1330	"	"
"	182	"	"	1415	"	"
"	183	"	"	1456	"	"
"	184	"	"	1532	"	"
"	185	"	"	1603	"	"
"	186	"	"	1626	"	"
"	187	"	"	1649	"	"
"	188	"	"	1717	"	"
"	189	"	"	1803	"	"
"	190	"	"	1827	"	"
"	191	"	"	1924	"	"
"	192	"	"	2020	"	"
"	193	July 26	207	1016	"	"
"	194	"	"	1042	"	"
"	195	"	"	1105	"	"
"	196	"	"	1130	"	"
"	197	"	"	1154	"	"
"	198	"	"	1221	"	"
"	199	"	"	1247	"	"
"	200	"	"	1315	"	"
"	201	"	"	1340	"	"
"	202	"	"	1405	"	"
"	203	"	"	1435	"	"
"	204	"	"	1500	"	"
"	205	"	"	1530	"	"
"	206	"	"	1605	"	"
"	207	"	"	1635	"	"
"	208	"	"	1657	"	"
"	209	"	"	1727	"	"
"	210	"	"	1800	"	"
"	211	"	"	1828	"	"
"	212	"	"	1854	"	"
"	213	"	"	1920	"	"
"	214	"	"	1945	"	"
"	215	"	"	2010	"	"
"	216	"	"	2032	"	"

Table 4-21. ATS-3 Data inventory
(continued)

Order by designation in this column		Date 1969		Time of picture (GMT)	Duplication cost	Availability date for distribution
		Calendar date	Julian day			
ATS	217	July 26	207	2101	Positive	2/1/71
"	218	"	"	2114	transparency	"
"	219	"	"	2140	$2.00 each.	"
"	220	July 27	208	1002	Print $1.50	"
"	221	"	"	1028	each.	"
"	222	"	"	1055	"	"
"	223	"	"	1120	"	"
"	224	"	"	1145	"	"
"	225	"	"	1210	"	"
"	226	"	"	1235	"	"
"	227	"	"	1303	"	"
"	228	"	"	1328	"	"
"	229	"	"	1400	"	"
"	230	"	"	1421	"	"
"	231	"	"	1458	"	"
"	232	"	"	1518	"	"
"	233	"	"	1553	"	"
"	234	"	"	1620	"	"
"	235	"	"	1648	"	"
"	236	"	"	1719	"	"
"	237	"	"	1744	"	"
"	238	"	"	1818	"	"
"	239	"	"	1843	"	"
"	240	"	"	1932	"	"
"	241	"	"	1957	"	"
"	242	"	"	2023	"	"
"	243	July 28	209	0950	"	"
"	244	"	"	1018	"	"
"	245	"	"	1042	"	"
"	246	"	"	1107	"	"
"	247	"	"	1131	"	"
"	248	"	"	1156	"	"